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ABSTRACT

This document contains supplemental materials for special needs high school students intended to facilitate their mainstreaming in regular welding classes. Teacher's materials precede the materials for students and include general notes for the instructor, suggestions, eight references, a class progress chart, a questionnaire on the usefulness of the supplemental materials, and an answer key to student worksheets. The student materials consist of nine color-coded instructional units on the following topics: math skills; blueprint reading: basic views; blueprint reading: welding symbols and abbreviations; joint design and structural shapes; welding terms; using welding references; general safety procedures; using machinery safely; and metallurgy. The units are self-paced and contain simplified line drawings, controlled text, vocabulary development, and math practice exercises. The units typically include the following materials: (1) an introduction; (2) the objective of the unit; (3) the objectives on which students will be assessed; (4) terms and pictures of equipment used in the unit and on the job; (5) verbal and illustrated step-by-step explanation of a skill or task; (6) skill sheets that contain paper and pencil exercises that develop and reinforce math skills; (7) activity sheets designed to increase student involvement and provide extra skill practice; (8) unit reviews involving identification, matching, multiple-choice, and short-answer exercises; and (9) checklists on which to evaluate student performance. (CML)

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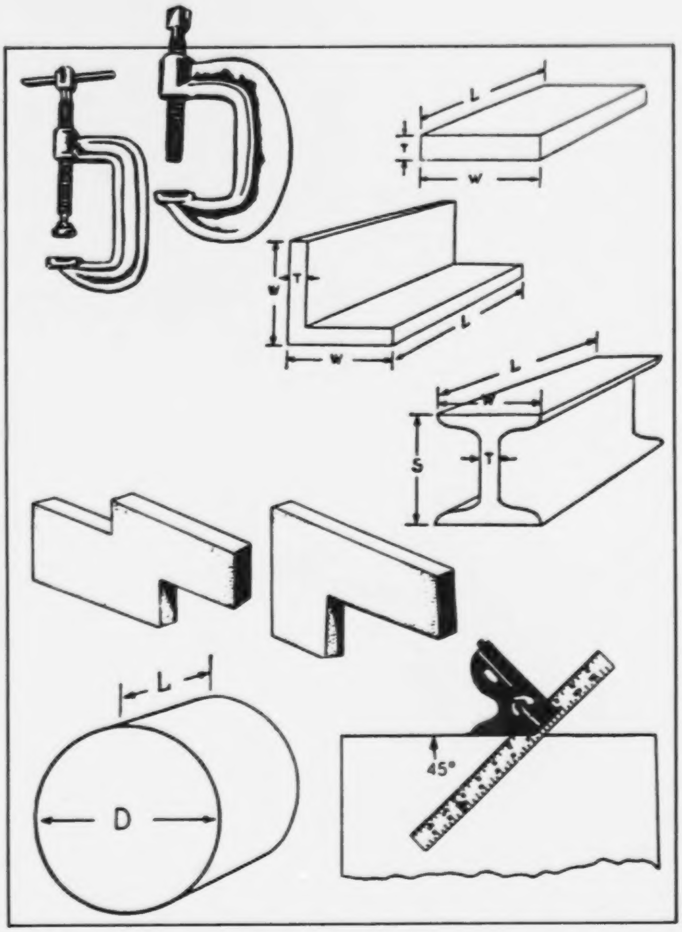
WELDING Supplementary Units



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Welding

Supplementary Units

by
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Columbia, Missouri

Catalog Number 90-9100-S

July 1988

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Welding Units

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Preface

Welding Supplementary Units are a Special Needs curriculum project sponsored by the Missouri Department of Elementary and Secondary Education. The purpose of this project is to provide supplementary materials for special needs students who are enrolled in regular Welding courses.

The special needs units should facilitate the mainstreaming of students with handicapping or disadvantaged conditions. The units are self-paced and contain simplified line drawings, descriptive text, vocabulary development, and math practice exercises. Units are color-coded as follows:

White: Introduction, Objectives, and Student Assessment - This page presents unit and specific objectives which the student must meet to successfully complete the unit. The introduction contains a brief motivational statement describing the purpose and content of the unit. Student Assessment allows the student to determine whether to study the material in the unit or take the unit exam.

Salmon: Terms and Equipment - This section introduces new terms and equipment necessary for the student to understand and perform the tasks shown in the unit.

Canary: Steps of Procedure - This presents a verbal and illustrated step-by-step explanation of a given skill or task.

Green: Skill Sheets - These pages provide paper and pencil exercises to develop and reinforce concepts and skills necessary to perform the procedures in the unit.

Blue: Activity Sheets - Various activities are presented to increase student involvement and provide extra practice in performing the procedures.

Pink: Unit Review and Performance Checklist - These sheets are used by the instructor to evaluate student performance. Different forms of review, including identification, matching, multiple-choice, and short answer exercises are provided.

These units were developed as hands-on materials for the special needs student and as a resource to assist the instructor. The instructor's responsibility is to adapt the material to particular teaching/learning situations.

Instructor's information, located in the front of the book, contains notes to the instructor, bibliography and answer keys.

Acknowledgements

This Welding supplementary guide results from the efforts of the following individuals:

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General Notes to the Instructor

Step 1: Read through the information in each unit before presenting it to the student.

Step 2: Make sure all equipment to be used in each unit is available.

Step 3: Prepare any handouts, visuals or supplemental material to aid student learning activities.

Step 4: Provide the student with the Introduction page.

Step 5: Discuss the tasks on the Introduction page and give directions for completing the "Are You Ready?" section.

Step 6: Have the student complete the Introduction page.

Step 7: If the student elects to complete the Unit Review and Performance Checklist and does so to your satisfaction, have him or her proceed to the next step.

Step 8: Discuss the Introduction page information with the student. At this time you can also discuss the Terms and Equipment lists.

Step 9: Provide the student with the Steps of Procedure section.

Step 10: Select a means to present the Steps of Procedure. (The means will depend on the student.) You might choose to:

a. Have the student study the information independently.
b. Go through the Steps of procedure individually or as a group.
c. Go through the material as a group; then have students work independently.

Step 11: Demonstrate the procedures to the student or class.

Step 12: Give the student time to practice the procedure. (You, the instructor, decide how much time they need.)

Step 13: Have the student complete all the skill sheets for the unit. Skill Sheets reinforce skills necessary to perform the procedures in the unit and may be used by the student as a self-evaluation tool or by the class as a discussion aid.

Step 14: Complete any applicable activities listed on the Activity Sheets.

Step 15: When the student is ready, use the Unit Review and Performance Checklist to evaluate the student's performance for that unit.

Additional Suggestions

- Try a team approach when possible:

  --Beginning students can work together after the instructor's demonstrations.

  --One student with experience in the procedure can work with a beginner.

- For non-readers or ESL students, audio-visuals of the lessons can be prepared.

- Review equipment with students whenever necessary.

- Each exercise can be used as a pencil and paper exercise or in any way you, the instructor, feel will best help to clarify the material.

- Additional modifications can be made to take care of other disadvantaged/handicapped conditions unique to your situation.

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Supplementary Units

Welding

Class Progress Chart

											STUDENT NAMES
											WHAT THE STUDENT CAN DO
											Use math skills
											Read from blueprints
											Use welding symbols and abbreviations
											Identify joint designs and structural shapes
											Use welding terms
											Use welding references
											Know welding safety rules
											Use machinery safely
											Identify properties of metals

Questionnaire

Staff members, writers and advisors have worked to make these instructional materials easy to use and easy to read. We welcome your input in the form of suggestions and/or corrections. Please return this questionnaire with your comments to:

Special Needs Editor
Instructional Materials Laboratory
10 London Hall
University of Missouri-Columbia
Columbia, Missouri 65211

Thank you for your time and consideration.

Welding Supplementary Units

Circle your overall rating of the publication:

Excellent Very Good Good Fair Poor

To improve the materials, IML should:

____

____

____

____

____

Other Comments:

____

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____

____

OPTIONAL

Name: ____

Address: ____

____

ANSWER KEY

Skill Sheet 1

1. 1/2
2. 1/4
3. 3/4
4. 5/6
5. 1/6
6. 1/8
7. 3/8
8. 2/6
9. 2/4
10. 3/6

Skill Sheet 2

1. 2/4
2. 1/2
3. 2/6
4. 6/8
5. 4/6
6. 2/8

Skill Sheet 3

1. one eighth of an inch
2. one inch
3. one half of an inch
4. one fourth of an inch
5. one eighth of an inch

Skill Sheet 4

1. a.
   b.
   c.
   d.
   e.

2. a.
   b.
   c.
   d.
   e.

UNIT REVIEW ANSWER KEY

1. a. 3/8
   b. 1/8
   c. 3/4
   d. 5/8
   e. 1/2
   f. 1/3
   g. 5/6
   h. 2/3

2. a. numerator
   b. below
   c. whole
   d. mixed
   e. inches
   f. fraction

3. 1. e
   2. d
   3. b
   4. c
   5. a

4. a.
   b.
   c.
   d.
   e.
   f.
   g.
   h.
   i.
   j.

ANSWER KEY

SKILL SHEET 1

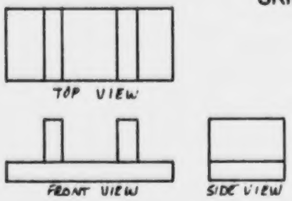
A. Object line
B. Extension line
C. Hidden line
D. Dimension line
E. Top view
F. End view
G. Side view

SKILL SHEET 2

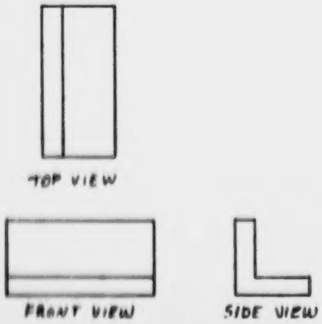
A. Phantom line
B. Object line
C. Hidden line
D. Cutting plane line or sectional line
E. Sectional view

SKILL SHEET 3

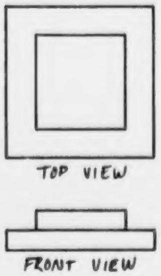
1.


TOP VIEW
FRONT VIEW
SIDE VIEW

2.


TOP VIEW
FRONT VIEW
SIDE VIEW

3.


TOP VIEW
FRONT VIEW

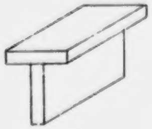
UNIT REVIEW

ANSWER KEY

1. A. Object line
   B. Hidden line
   C. Extension line
   D. Dimensional line
   E. Sectional or cutting plane line

2. A. Top view
   B. End view
   C. Side view
   D. Sectional view
   E. Working view
   F. Isometric view

3.



SKILL SHEET 1 ANSWER KEY

	Arrow Side	Other Side
1.	A	B
2.	A	B
3.	A	B
4.	B	A
5.	A	B
6.	B	A
7.	B	A
8.	A	B
9.	A	B
10.	B	A

SKILL SHEET 2 ANSWER KEY

	Arrowside	Otherside
1.	fillet weld etc.	
2.		fillet weld concave finish
3.	fillet weld 1/4" leg length flush finish	fillet weld 1/4" leg length concave finish
4.	fillet weld .875" leg length finish flush	fillet weld
5.		fillet weld
6.	fillet weld 1/8" leg length finished convex	fillet weld finished convex
7.	fillet weld .500" leg length finished flat	fillet weld finished flat

SKILL SHEET 3 ANSWER KEY

	Arrowside	Otherside
1.	fillet weld .250" leg length 3" weldment 9" pitch	fillet weld .250" leg length finished flat 3" weld 9" pitch staggered interm.
2.		fillet weld finished concave 2" weld 9" pitch
3.	fillet weld 1/4" leg length finished convex 4" weld 10" pitch	fillet weld 3/8 leg length finished convex 4" weld 10" pitch chain interm.
4.	fillet weld 2" weldment 9" pitch	
5.	fillet weld .875" leg length 5" weld 12" pitch	fillet weld 1" leg length finished flat

Unit Review Answer Key

	Arrowside	Otherside	Additional Ref Info
1.	fillet weld 1/2" leg length		
2.	fillet weld	fillet weld	typical size for print
3.	fillet weld 1/4" leg length 2" weld 5" pitch	fillet weld 1/4" leg length 2" weld 5" pitch chain intermittent	
4.		fillet weld .250" leg length finished convex 2" weld 9" pitch	field weld use SMAW 5/32 E7024 electrode
5.	fillet weld finished concave	fillet weld finished concave	
6.	fillet weld 1/4" leg length		use SMAW field weld weld-all-around
7.	fillet weld 1/4" leg length finished convex electrode		weld-all-around Use GTAW & 1/8" E308
8.	fillet weld finished flat		see note 1 on print
9.	fillet weld 1/4" leg length	fillet weld 1/4" leg length	field weld weld-all-around see Note #27 on print

XVi

UNIT REVIEW ANSWER KEY

1. A. Tee Joint
   B. Lap Joint
   C. Butt Joint
   D. Edge Joint
   E. Corner Joint

2. Amount and type of stress that will be placed on the joint.
   Time required to make the weld.
   Cost making the weld.
   Shape of the object that is being built.
   Whether the joint can be welded from more than one side.

3. A. Strip
   B. Flat
   C. Channel
   D. Angle
   E. Round
   F. Pipe
   G. Wide Flange beam
   H. S (I) beam
   I. Plate
   J. Sheet

4. A. 2" X 2" X 1/5" X 20' angle
   B. 8" X 12# X 12' channel
   C. 2" X schedule 40 X 12' pipe
   D. 8" X 6" X 20# X 16' S(I) beam
   E. 2" X 40" X 8' plate

SKILL SHEET 1

BASIC TERMS

Directions: Fill in each blank below with the welding term that fits the statement.

adhesion
base metal
inert gases
arc blow
filler metal
kerf
backfire
fusion
flashback

1. arc blow is when the arc wavers from its normal path because of magnetic disturbance.
2. base metal is the metal to be welded.
3. kerf is the space made when metal has been cut.
4. adhesion is a way of joining metals together without melting them.
5. fusion means melting metals together to join them.
6. inert gases such as argon, helium or argon-hydrogen, do not normally combine chemically with the molten base metal.
7. backfire causes a loud "pop" when the oxyacetylene flame goes out.
8. filler metal is the metal added when making fusion, brazed or soldered welds.
9. flashback is when the oxyacetylene flame burns back into the welding tip or torch.

SKILL SHEET 2

TERMS THAT DESCRIBE CHARACTERISTICS OF METAL

Directions: Circle the correct terms to finish each sentence below.

1. Welds and casted metals can contain (alloys, [✓ inclusions]), which are small particles.
2. When metal is exposed to air, ([✓ oxides], ferrous metals) form on the metal surface.
3. Gas pockets, small particles or empty spaces in a weld are signs of ([✓ porosity], oxides).
4. Copper, Aluminum, lead and zinc are all (ferrous, [✓ nonferrous]) metals.
5. Iron and steel are ([✓ ferrous], nonferrous) metals.
6. ([✓ Elongation], stress) is another word for stretching.
7. How much pulling a metal can withstand depends on the metal's (yield strength, [✓ tensile strength]).

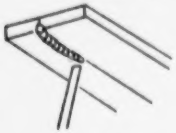
SKILL SHEET 3

TERMS THAT DESCRIBE WELDING POSITIONS AND SPECIAL TYPES OF WELDS

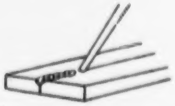
Directions: Use the new terms you have learned to identify the pictures below.

flat
horizontal
vertical
overhead
plug weld
slot weld
spot weld
tack weld

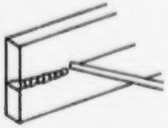
1. Here are the four main welding positions. In the space beneath each picture, write the name of the position shown.



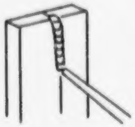
a. overhead



b. flat

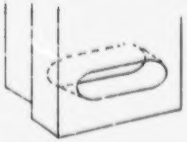


c. horizontal

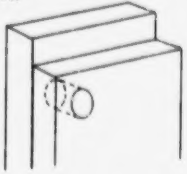


d. vertical

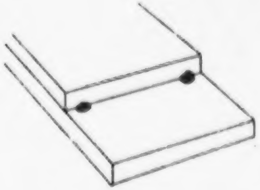
2. Here are some special types of welds. In the space beneath each picture, write the name of the weld shown.



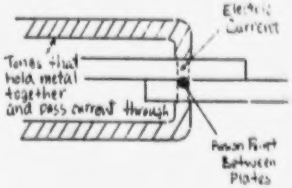
a. slot weld



b. plug weld



c. tack weld


Electric Current
Tongs that hold metal together and pass current through
Fusion Point Between Plates

d. spot weld

ACTIVITY SHEET 1

WORKING WITH WORDS

Directions: Your instructor will give you a reading assignment in your textbook or in material he provides. After you read the assignment:

1. Check off the steps below that you followed.

- ✓ Looked for words in large or dark print.
- ✓ Wrote down new words.
- ✓ Found the meaning of new words.
- ✓ Asked "what's the point of this?," "what can I learn from this?" and "why did the writer give this information?"
- ✓ Read hard-to-understand material over again.
- ✓ Took notes.

2. List two new words you found and tell what they mean.

a. WILL VARY FROM STUDENT
TO STUDENT

b. WILL VARY FROM STUDENT
TO STUDENT

3. Make notes that tell the main points you learned from the reading.

WILL VARY FROM STUDENT
TO STUDENT

XX

SKILL SHEET 4

WELDING ABBREVIATIONS

Directions: This chart shows abbreviations commonly used in welding. Some of the words and abbreviations are missing. Complete the chart by writing the correct word or abbreviation in each empty space.

1.	Alternating Current	A.C.
2.	American Welding Society	A.W.S.
3.	American Wire Gauge	A.W.G.
4.	Angle	∠
5.	British thermal unit	B.T.U.
6.	Center Line	℄
7.	Cold rolled steel	C.R.S.
8.	Cubic feet per minute	C.F.M.
9.	Diameter	Dia.
10.	Detail	Det.
11.	Direct Current	D.C.
12.	Figure	Fig.
13.	Gauge	Ga.
14.	Hot Rolled Steel	H.R.S.
15.	Inside diameter	I.D.
16.	Outside diameter	O.D.
17.	Radius	rad. (or r.)
18.	Revolutions Per Minute	r.p.m.

WELDING TERMS

UNIT REVIEW

1. Match each term below with its correct definition.

arc blow
fusion
kerf
stress
adhesion

a. fusion joining metals by melting them together

b. adhesion joining metals together without melting them

c. arc blow the wavering of an arc from its normal path because of magnetic disturbance

d. kerf the space made when metal has been cut

e. stress the load or amount of force put on an object

2. Write the word in the blank that best completes each statement.

a. alloy is a material made up of a metal and another element.

b. yield strength is the stress point at which metal becomes permanently deformed.

c. tensile strength is the ability of a metal to withstand a force trying to pull the metal apart.

d. non-ferrous metal is metal that contains no iron.

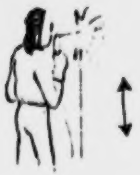
e. ferrous metal is metal that contains iron.

3. Write the abbreviation or symbol for each of these words.

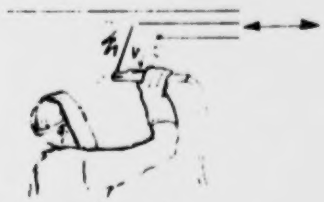
a.	Alternating current	A.C.
b.	Angle	∠
c.	Center line	℄
d.	Cold rolled steel	C.R.S.
e.	Cubic feet per minute	C.F.M.
f.	Diameter	Dia.
g.	Direct current	D.C.
h.	Gauge	Ga.

4. Here are pictures of welders at work. In the space beneath each picture, write the name of the position shown. The four main welding positions are:

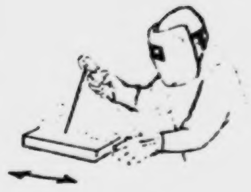
flat horizontal vertical overhead



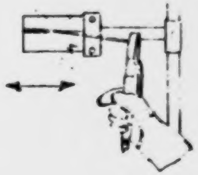
a. vertical



b. overhead

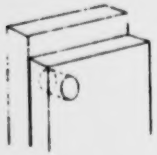


c. flat

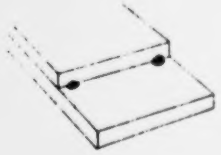


d. horizontal

5. Here are some special types of welds. In the space beneath each picture, write the name of the weld shown.



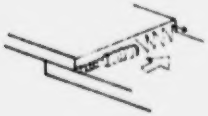
a. plug

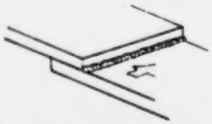


b. tack

6. Fill in the blanks beside each picture to tell what the picture shows. Use these terms:

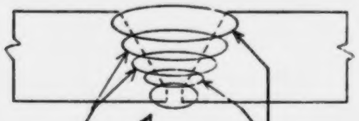
hot pass	stringer bead	filler pass
weaving bead	cover pass	root pass





a. weaving bead

b. stringer bead or root pass



c. filler pass

d. root pass

e. hot pass

f. cover pass

7. Tell two steps you can take to learn new terms.

a. Ask your instructor.

b. Look up terms in a glossary or dictionary

(others as appropriate.)

8. Tell two steps you can take to help understand and remember better when reading.

a. Make an outline as you read.

b. look for highlighted words.

(write down questions you want answered before reading; look at the title.)

(others as appropriate)

WELDING SUPPLEMENTARY UNITS
USING WELDING REFERENCES

ANSWER KEY

Skill Sheet 1
1. table of contents
2. glossary
3. appendix
4. index
5. table of contents
6. index, glossary
7. glossary
8. table of contents, index

Activity Sheet 1
Answers will vary depending upon reference supplied by the instructor.

Skill Sheet 2
Decide what information you need.
Decide which reference is likely to contain the information.
Look up the information in the reference.
Read the information.
Apply the information to the job being done.

Skill Sheet #3
1. AW205
2. 40
3. 10 psi Oxygen and 10 psi Acetylene
4. AW207
5. 11 psi Oxygen and 11 psi Acetylene

Skill Sheet #4
1. 75-130
2. 50-80
3. 325-440
4. 300-380
5. 90-160
6. 280-425
7. 250-300
8. 90-150
9. 360-520
10. 200-280

Unit Review
1. table of contents
2. glossary
3. appendix
4. index
5. rows
6. columns
7. a. 3 b. 2 c. 5 d. 1 e. 4

ANSWER KEY

SKILL SHEET 1

1. Boots - cover ankles
   no holes
   preferably steel toes
2. Approved safety glasses and welding helmet with proper shade of filter lens.
3. Non-flammable clothing
   leathers if desired
4. Gloves
5. Helmet

SKILL SHEET 2

1. Any of the below
   a. use exhaust fans
   b. open outside doors
   c. use direct capture equipment
   d. make sure containers are properly vented when working inside them
2. 1. F 2. T 3. F 4. F 5. T

SKILL SHEET 3

1. T
2. F
3. F
4. T
5. F
6. F
7. T
8. F
9. T
10. F

UNIT REVIEW

1. F
2. F
3. T
4. F
5. T
6. T
7. F
8. T
9. T
10. T
11. F
12. T
13. F
14. T
15. F
16. T
17. T
18. F
19. T
20. F

UNIT REVIEW

ANSWER KEY

1. a. (Various answers are correct.)
   b. (Various answers are correct.)
   c. (Various answers are correct.)

2. A. chuck
   B. lock
   C. center punch
   D. reduce
   E. clamped or fastened
   F. blade
   G. close
   H. clean
   I. 1/8
   J. side
   K. replace or discard
   L. unplug
   M. disc
   N. away
   O. stopped
   P. side
   Q. clothing

METALLURGY

ANSWER KEY

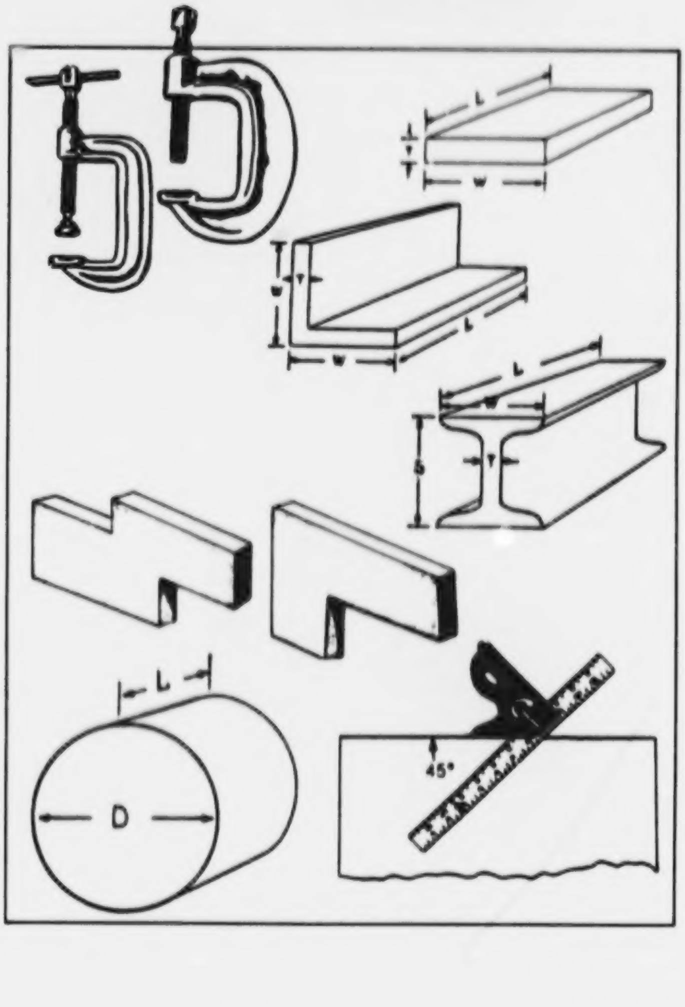
ACTIVITY SHEET 1

All items should be checked as the student watches the demonstration.

UNIT REVIEW

1. c
2. d
3. a
4. b
5. e
6. Metal expands when it is heated.
   Metal contracts when it cools.
7. Any three of the following:
   use
   appearance
   rust resistance
   cost to make
   cost to weld
   cost for the consumer to buy
   strength
   weight of the finished product
8. a, b, d and e should be checked
9. a. White Cast Iron
   b. High Carbon Steel
   c. Wrought Iron
   d. Low Carbon Steel
   e. Malleable Cast Iron

WELDING Supplementary Units


L
T
W
L
T
W
W
L
L
W
S
T
L
D
45°

Math Skills

MATH SKILLS

INTRODUCTION

Welders need both the ability to measure objects accurately and the ability to add, subtract, multiply and divide fractions or decimals. Welders use these skills each day when they measure objects, figure dimensions and communicate with other workers.

UNIT OBJECTIVES

When you finish this unit, you should be able to read a measuring device to the nearest eighth (1/8) of an inch and perform mathematical operations that use fractions and decimals.

SPECIFIC OBJECTIVES

After finishing this unit, you should be able to specifically:

1. Recognize that fractions represent parts of a whole.
2. Correctly read a measuring device to the nearest eighth (1/8) of an inch.
3. Measure lines and objects.
4. Solve math problems that use fractions. (Be able to add, subtract, multiply and divide them.)

ARE YOU READY?

CHECK THE STATEMENT THAT IS TRUE FOR YOU:

☐ **I can do these tasks and want to go through the Performance Checklist.**

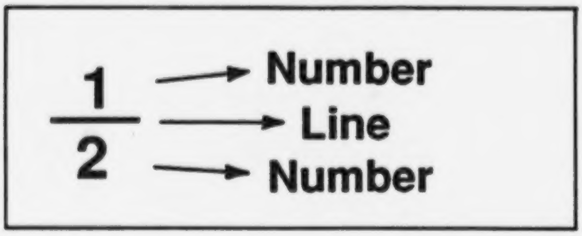
SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

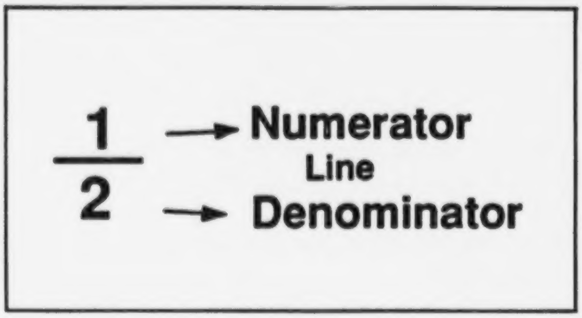
A. Terms

1. **Fraction** - a symbol that uses numbers above and below a line to describe part of a whole object. "1/2" (one half) is a fraction.



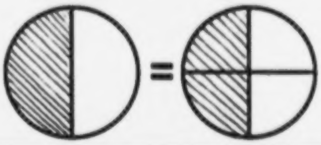
2. **Numerator** - the number above the line in a fraction.

3. **Denominator** - the number below the line in a fraction.



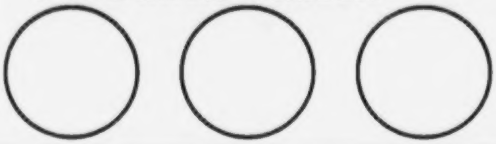
4. **Equivalent fractions** - fractions that use different numbers but have equal values.

$$\frac{1}{2} = \frac{2}{4}$$



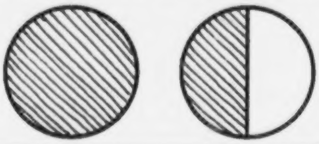
5. **Whole Number** - a number that represents a whole object.

There are 3 whole objects.
3 is a whole number.

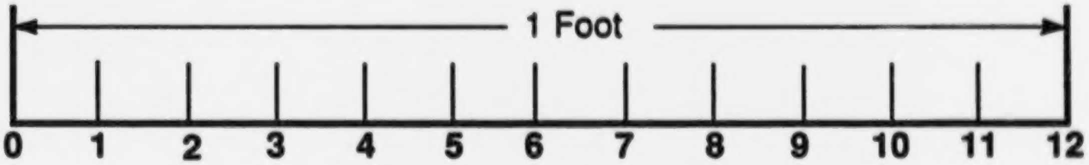


6. **Mixed Number** - a number that contains both a whole number and a fraction.

There are 1 and 1/2 shaded objects. 1 1/2 is a mixed number.

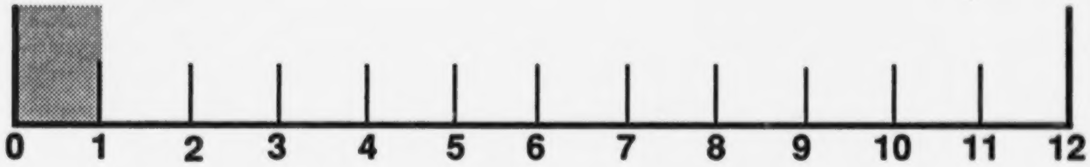


7. **Foot** - a foot is a unit of measurement. One foot is 12 inches long.


1 Foot
0
1
2
3
4
5
6
7
8
9
10
11
12

12 Inches equals 1 Foot

8. **Inch** - a unit of measurement smaller than a foot. Since there are twelve inches in a foot, an inch is one twelfth (1/12) of a foot.


0
1
2
3
4
5
6
7
8
9
10
11
12

1 Inch equals 1/12 of a Foot

Equipment

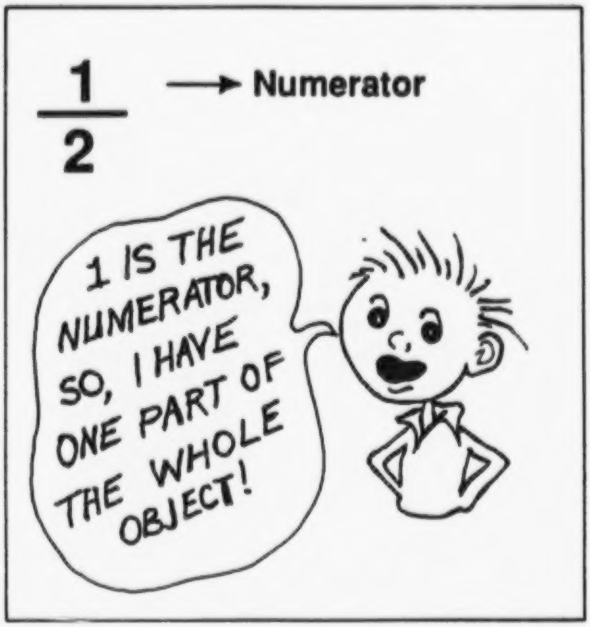
Paper

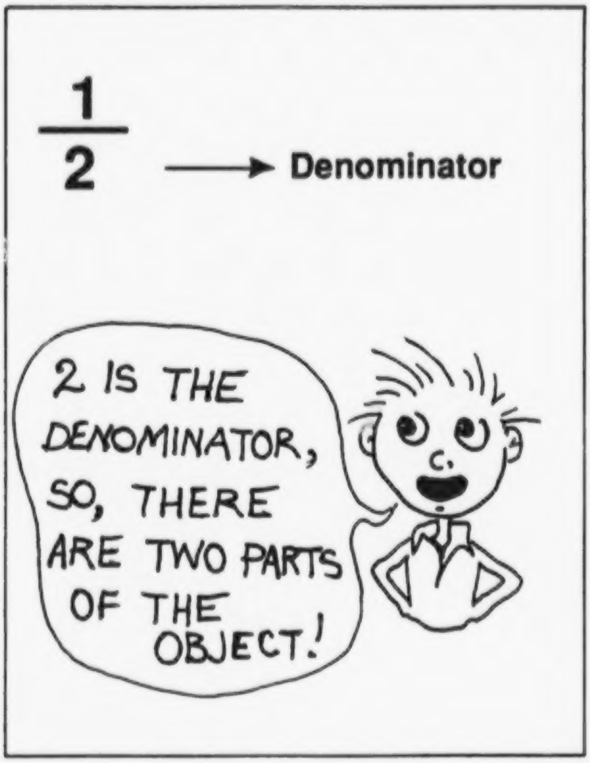
Pencil

Tape Measure

Ruler

B. Recognizing the Meaning of Fractions


1/2 → Numerator
1 IS THE NUMERATOR, SO, I HAVE ONE PART OF THE WHOLE OBJECT!


1/2 → Denominator
2 IS THE DENOMINATOR, SO, THERE ARE TWO PARTS OF THE OBJECT!

1. A fraction is a symbol that uses numbers above and below a line to describe part of a whole object.

2. The number above the line in a fraction is called the numerator.

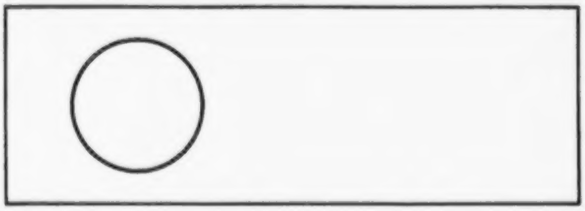
3. The numerator tells how many equal-sized parts of the whole object you have.

4. The number below the line in a fraction is called the denominator.

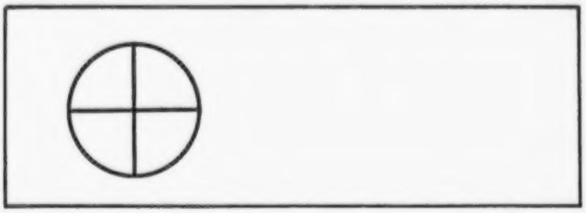
5. The denominator tells how many equal-sized parts are in the whole object.

6. If you cut and eat one half (1/2) of a pie, one (1) of two (2) total pieces of the pie goes to your stomach, and the other piece is left over.

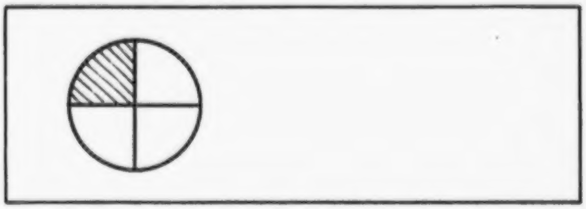
7. Here's an example that shows how to write a fraction, which represents part of a whole object.



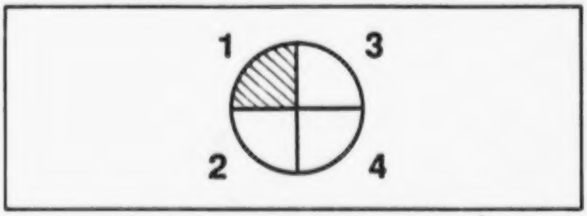
8. The circle at the right has been divided into four (4) equal parts.



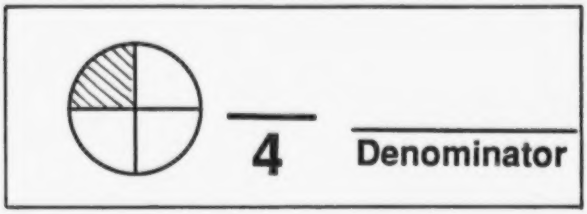
9. Now we shade one of the parts. Let's make a fraction that shows how much of the circle has been shaded.



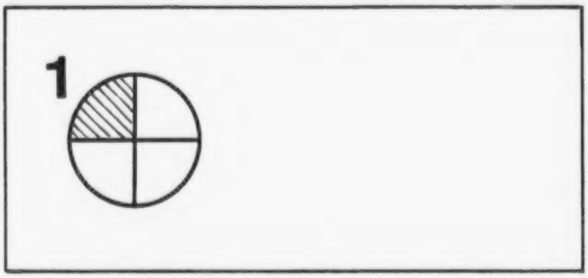
10. First, we need to know how many parts are in the whole circle. Let's count them.



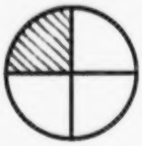
11. Since there are four (4) parts in the whole circle, the denominator (bottom number) in our fraction will be "4."



12. Next we need to know how many parts of the circle have been shaded. Let's count them.

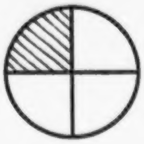


13. Since only one (1) part of the circle has been shaded, "1" will be the numerator (top number) in our fraction.



1 _____ **Numerator**

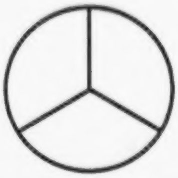
14. Now we know that one fourth (1/4 or "one quarter") of the circle has been shaded.



$\frac{1}{4}$

15. Let's review the steps for writing a fraction that represents part of a whole object.

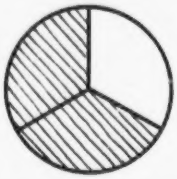
    a. Count the number of parts in the whole object.



    b. Write this number below the line. It is the denominator of the fraction.

_____ **Denominator**

    c. Count the number of equal parts you want to shade or group together.



d. Write this number above the line. It is the numerator of the fraction.

______ $\underline{\text{Numerator}}$

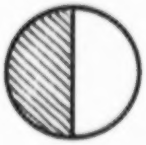
e. You have now made a fraction with a numerator and a denominator.

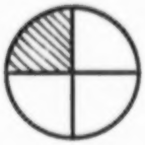
______ $\frac{\text{Numerator}}{\text{Denominator}}$

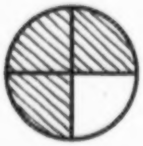
DO SKILL SHEET 1

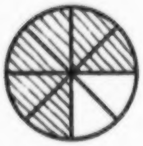
SKILL SHEET 1

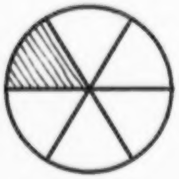
Look at the circles below. Write a fraction that tells how much of each circle has been shaded. Number one has been done already to show you how.

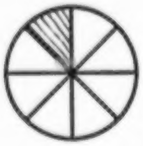
1.  $\frac{1}{2}$

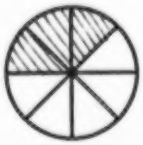
2.  ________

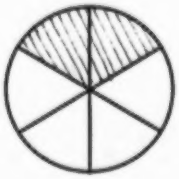
3.  ________

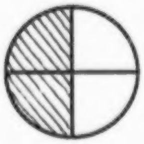
4.  ________

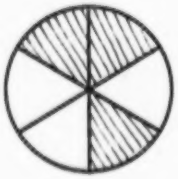
5.  ________

6.  ________

7.  ________

8.  ________

9.  ________

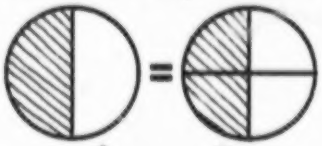
10.  ________

C. Recognizing Equivalent Fractions

1. Equivalent fractions are fractions that have equal values.

2. Two fractions are equivalent when they have different numerators and denominators but represent the same amount of the whole object.

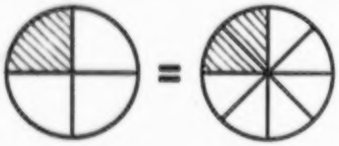
These fractions are equivalent fractions.



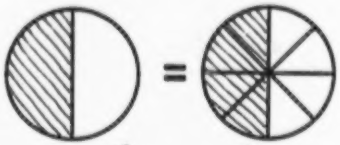
$$\frac{1}{2} = \frac{2}{4}$$

3. One half and two fourths (1/2 and 2/4) are equivalent fractions because they both represent the same amount of a whole object.

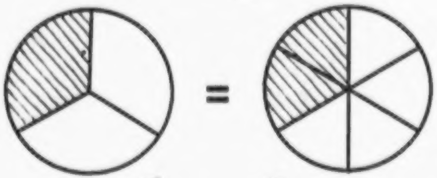
4. Other equivalent fractions are shown at the right. Remember, equivalent fractions are fractions that have different numerators and denominators but represent the same amount of a whole object.



$$\frac{1}{4} = \frac{2}{8}$$



$$\frac{1}{2} = \frac{4}{8}$$

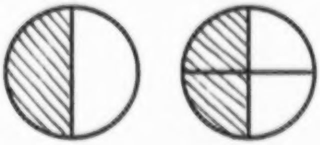


$$\frac{1}{3} = \frac{2}{6}$$

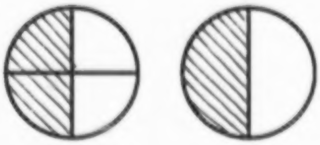
DO SKILL SHEET 2

SKILL SHEET 2

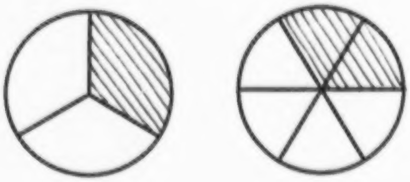
Look at each pair of circles below. Write the correct equivalent fraction for each circle. Number one has been done already to show you how.

1. 

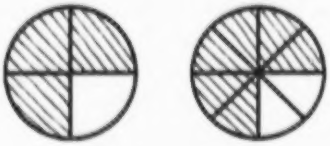
$\frac{1}{2} = \frac{2}{4}$

2. 

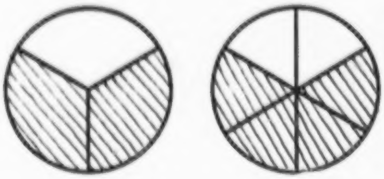
$\frac{2}{4} = \_\_\_$

3. 

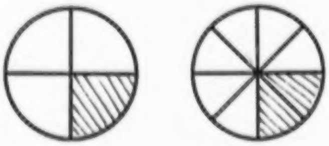
$\frac{1}{3} = \_\_\_$

4. 

$\frac{3}{4} = \_\_\_$

5. 

$\frac{2}{3} = \_\_\_$

6. 

$\frac{1}{4} = \_\_\_$

D. Recognizing the Divisions on a Ruler

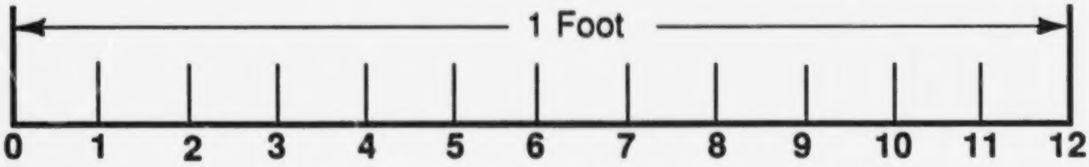
1. The ability to read a measuring device, such as a ruler or steel tape, is very important to a welder.

2. Often welders use these tools to measure pieces of metal before cutting or welding.

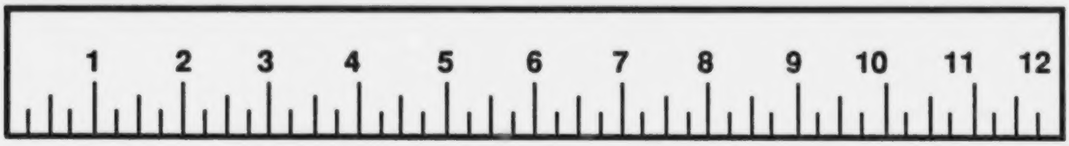
3. Let's look at a ruler and learn the divisions on it.

   NOTE: The divisions on a steel tape are the same as those on a ruler.

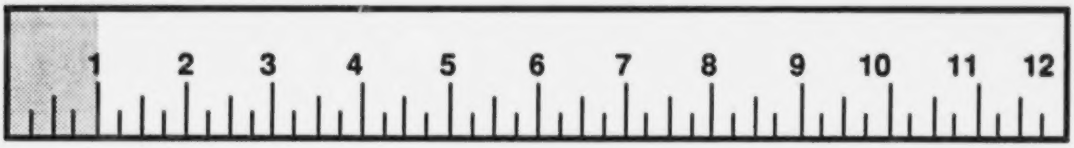
4. Rulers are one (1) foot long. A foot is equal to 12 inches.



5. Each ruler is divided into 12 equal parts. Each of these parts is an inch.


1
2
3
4
5
6
7
8
9
10
11
12

6. Since there are 12 inches in a foot, each inch is one twelfth (1/12) of a foot.


1
2
3
4
5
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7
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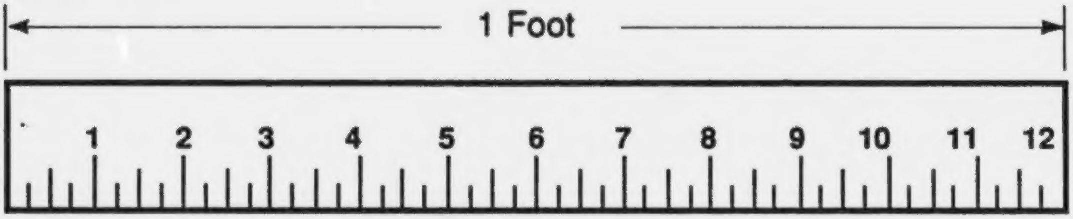
10
11
12

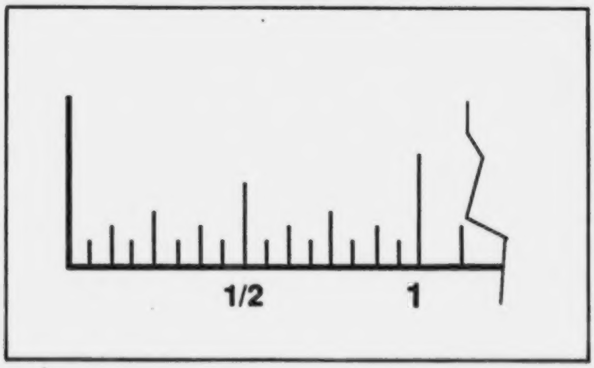
7. Remember:

- Rulers are one (1) foot long.
- Each ruler is divided into 12 equal parts, called inches.
- Each inch is one twelfth (1/12) of a foot.

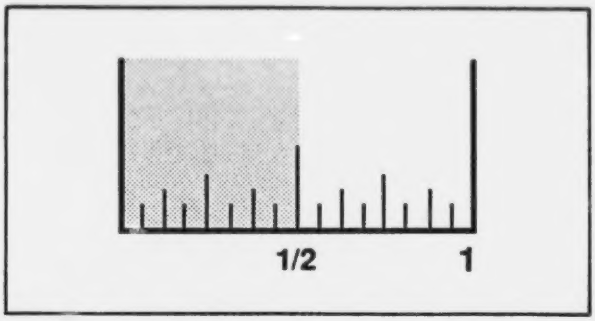
8. We have just learned that each foot is divided into 12 smaller parts, called inches.



9. Now we will learn that each inch is also divided into smaller parts. These smaller parts are called fractions of an inch.

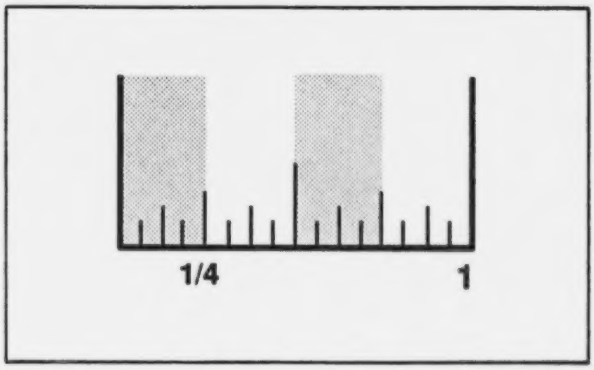


10. Each inch can be divided into two equal parts. Each one of these parts is one half (1/2) of an inch.

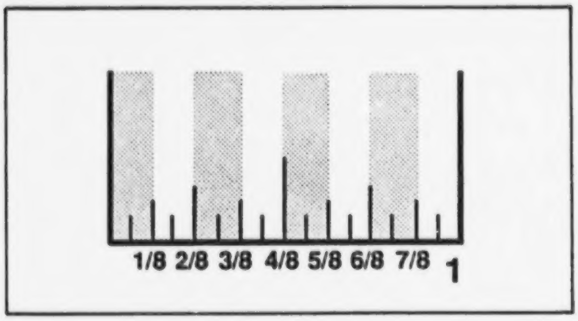


11. Next, the two equal parts can be cut in half again, dividing the inch into four (4) equal parts.

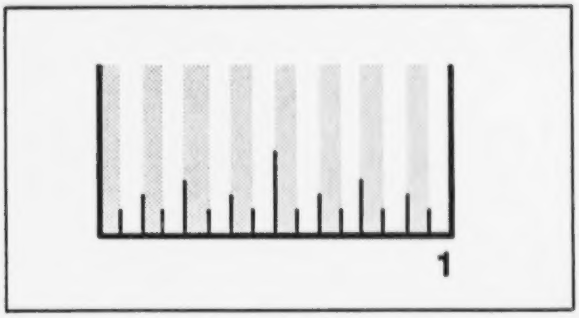
    Each one of these parts is one fourth (1/4 or "one quarter") of an inch.



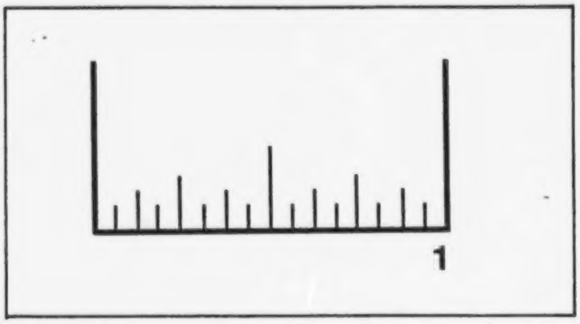
12. Each quarter can be cut in half again, dividing the inch into eight (8) equal parts. Each one of these parts is one eighth (1/8) of an inch.



13. In the same way, the inch can be divided into 16 equal parts. Each of these parts is one sixteenth (1/16) of an inch.



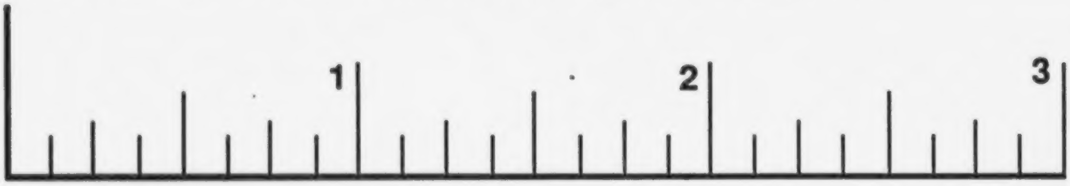
14. Now you should be able to recognize fractional parts of an inch.



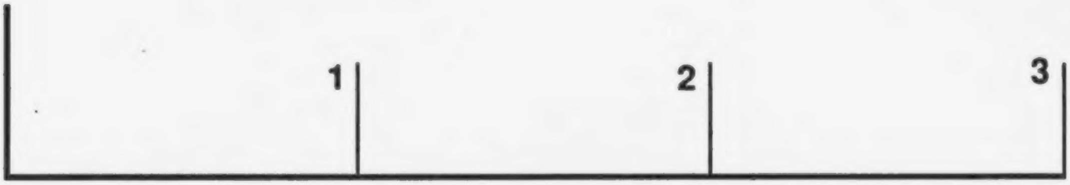
DO SKILL SHEET 3

SKILL SHEET 3

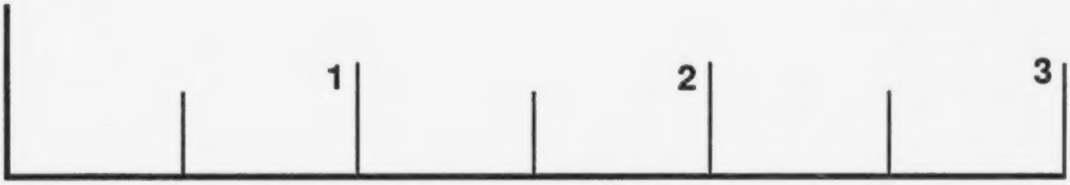
Look at each ruler below. Count the divisions per inch and determine if the smallest division on the ruler is one inch, one half of an inch, one quarter of an inch or one eighth of an inch. Write your answer in the blank beside each ruler. Number 1 has been done already to show you how.



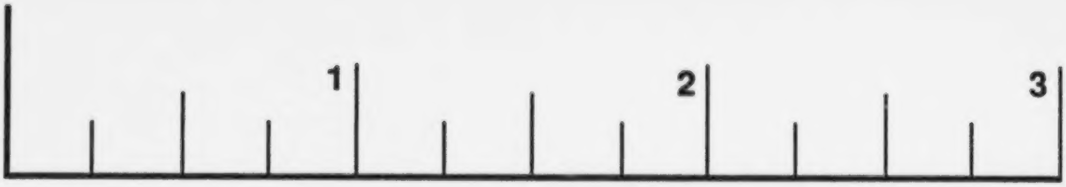
1. one-eighth inch



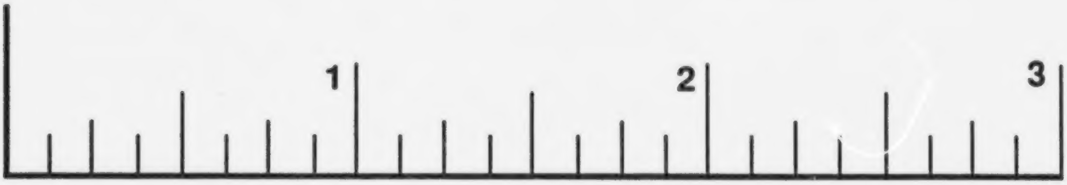
2. ____________________



3. ____________________

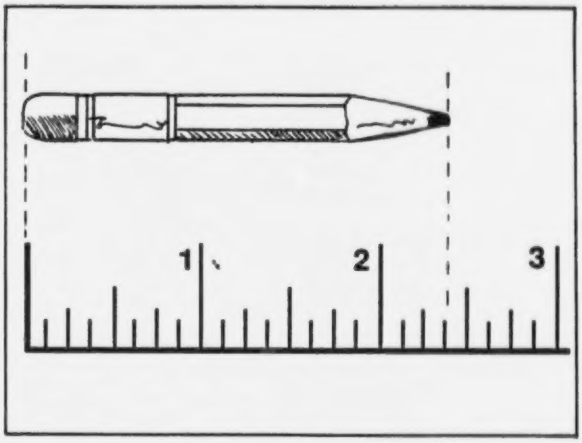


4. ______________



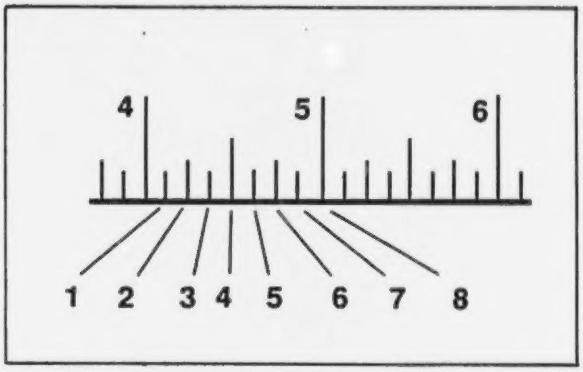
5. ______________

E. Measuring Objects with a Ruler



1. Now that you know inches can be divided on a ruler, you are ready to learn how to use the ruler to measure objects.

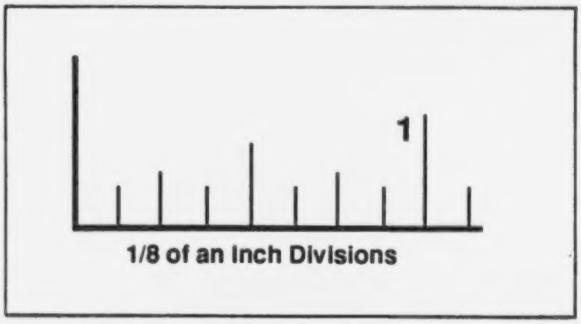
2. Before you can measure an object, you must check how many divisions per inch your ruler has.



3. Find the number of divisions per inch by counting the lines within one inch on the ruler.

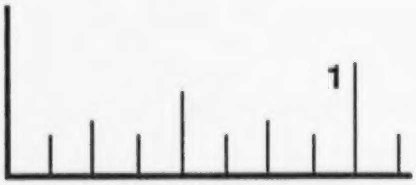
   Start at one of the inch marks and count the lines up to, and including, the next inch mark.

   (Note: Don't count the inch mark you start on.)



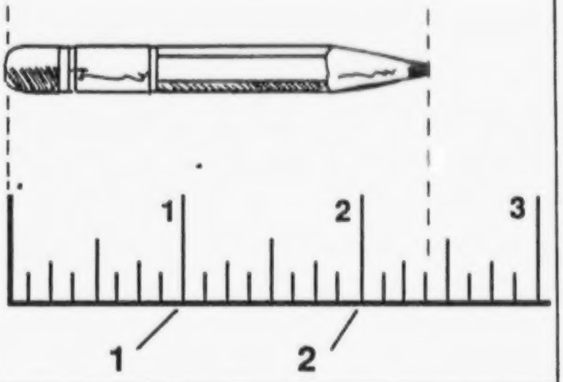
4. Once you know how many lines there are between inch marks on your ruler, you know what fraction of an inch each line represents.

5. For example, if there are eight lines between inch marks, each line marks off one eighth (1/8) of an inch.



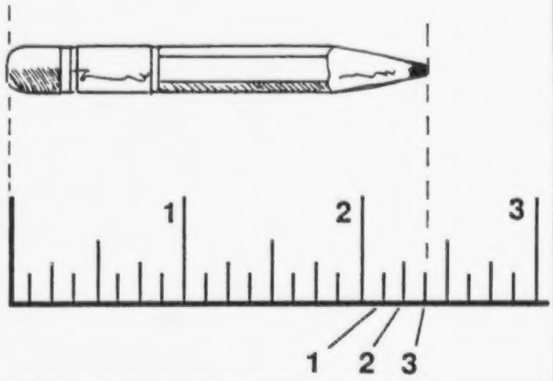
1/8 of an Inch Divisions

6. To measure an object with a ruler, place the ruler so the zero end is even (flush) with the end of the object to be measured.



7. Count the number of full inch marks between the end of the ruler and the end of the object being measured. The count will tell you the number of full inches in the measurement.

8. Next, count the number of lines between the last full inch mark and the end of the object being measured. This will give you the leftover (fractional) parts of an inch in the measurement.



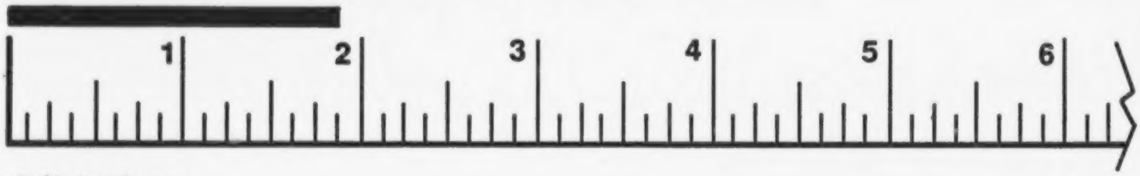
9. Finally, add the whole inches and the leftover (fractional) parts of an inch together to get the total measurement for the object.

$$2\frac{3}{8}$$

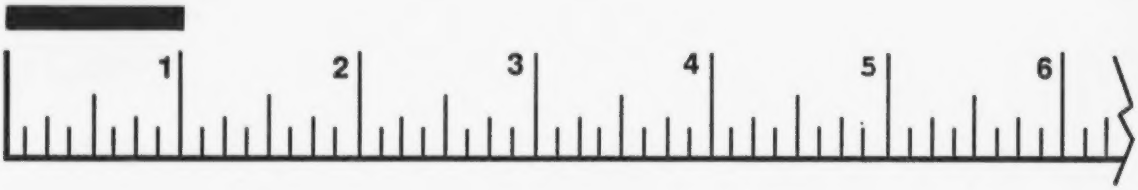
DO SKILL SHEET 4

SKILL SHEET 4

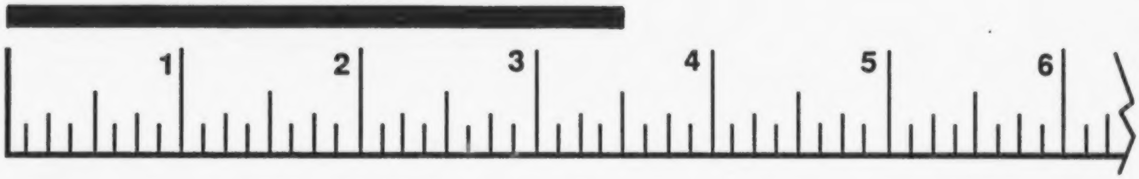
1. A bar is drawn above each of the rulers below. Read the ruler to find the length of each bar. Write your answer in the blank. Number one has been done already to show you how.



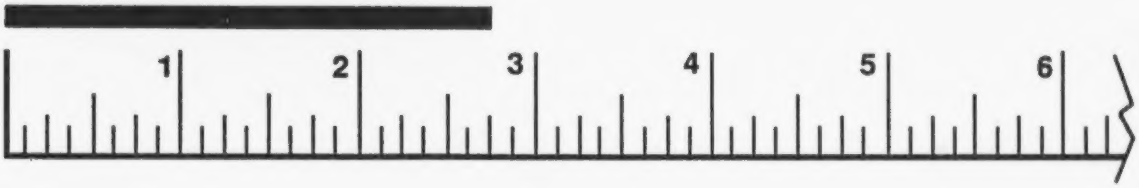
a. 1 7/8 inches



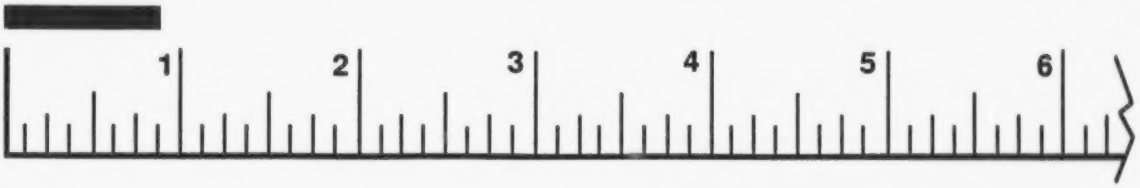
b. ________________



c. ________________



d. ________________



e. ________________

2. Your instructor will provide you with a ruler. Measure the length of each line below to the nearest one eighth of an inch. Record your measurement in the blank.

_______ a.

_______ b.

_______ c.

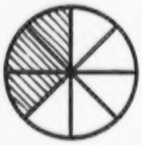
_______ d.

_______ e.

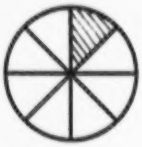
UNIT REVIEW

1. Write a fraction that tells how much of each circle below has been shaded. The first exercise has been done already to show you how.

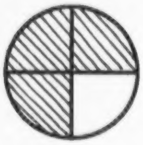
$\frac{3}{8}$ a.



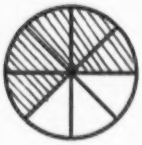
______ b.



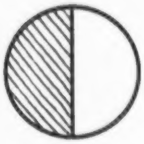
______ c.



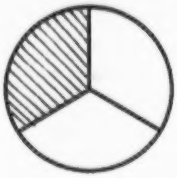
______ d.



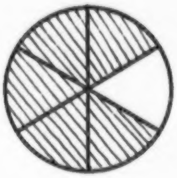
______ e.



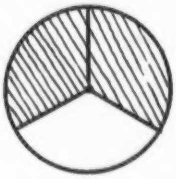
______ f.



______ g.



______ h.



2. Fill in the blanks to complete each sentence correctly.

   a. The number above the line in a fraction is called the ______________________ .

   b. The denominator is the number ______________ the line in a fraction.

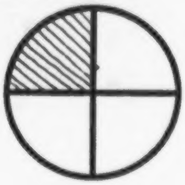
   c. 1, 2, 3, 10, etc. are all examples of ______ numbers.

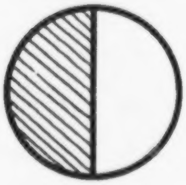
   d. 1 1/2, 6 1/2, 8 3/4, etc. are all examples of ______________ numbers.

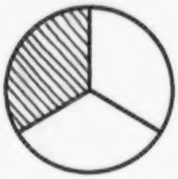
   e. It takes twelve (12) _______ to equal 1 foot.

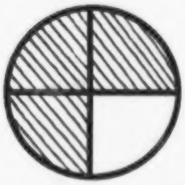
   f. A ____________________ is a symbol that uses numbers above and below a line to describe part of a whole object.

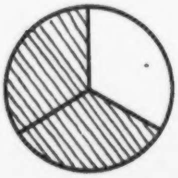
3. Match each fraction and shaded circle on the left with the equivalent (equal) fraction and shaded circle on the right. Place the letter of the correct answer in the blank. The first problem has been done already to show you how.

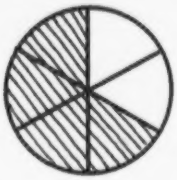
_____ 1.  $\frac{1}{4}$

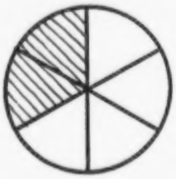
_____ 2.  $\frac{1}{2}$

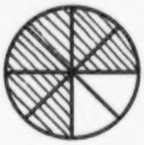
_____ 3.  $\frac{1}{3}$

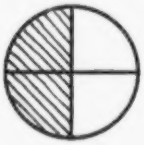
_____ 4.  $\frac{3}{4}$

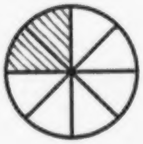
_____ 5.  $\frac{2}{3}$

a.  $\frac{4}{6}$

b.  $\frac{2}{6}$

c.  $\frac{6}{8}$

d.  $\frac{2}{4}$

e.  $\frac{2}{8}$

4. Get a ruler from your instructor. Measure each of the lines to the nearest one eighth (1/8) inch. Record your measurement in the blanks.

______ a. ________________________

______ b. ____________________________________

______ c. _______________

______ d. ____

______ e. ____

______ f. _____________________

______ g. ________________________

______ h. __________________________________

______ i. ________

______ j. ____

PERFORMANCE CHECKLIST

Student ______________________________ successfully performed the following tasks:

	Yes	No	Comments
1. Showed instructor how fractions represent part of a whole			
2. Correctly read a measuring device to the nearest one sixteenth of an inch			
3. Measured several lines and objects			
4. Performed mathematical operations that involved the use of fractions			

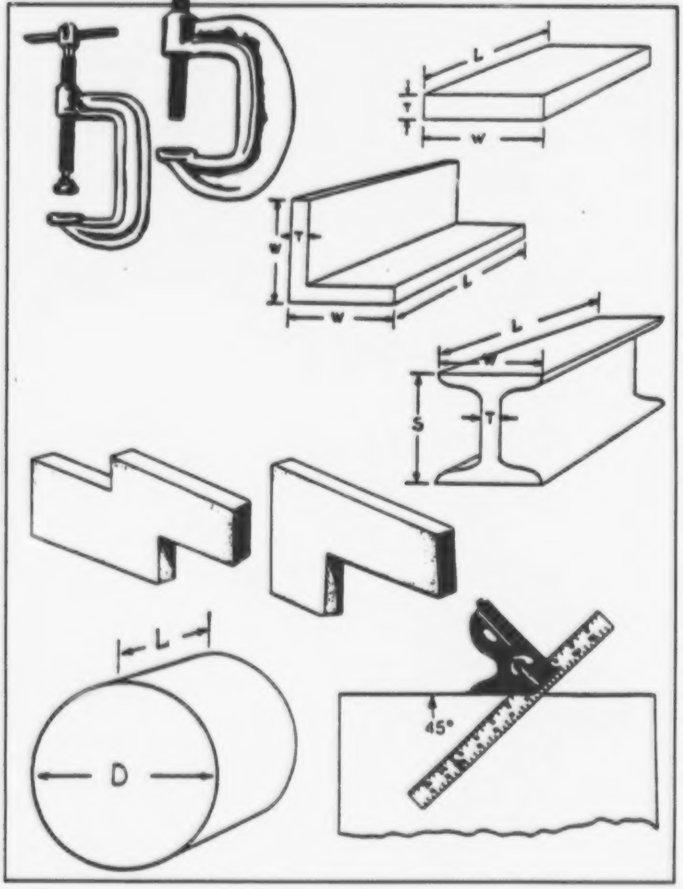
Satisfactory - should move on ☐

Should repeat this unit ☐

____________________________ Student's Signature/Date

____________________________ Instructor's Signature/Date

WELDING Supplementary Units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Blueprint Reading Basic Views

BLUEPRINT READING: BASIC VIEWS

INTRODUCTION

Because blueprints are the "sign language" of industry, blueprint reading is an important skill for welders. Often parts of a product are manufactured in different areas of a plant, city, state or country. When the parts are put together, everything must fit correctly. When the parts fit, everyone followed the blueprint.

The welder must know how to read prints because they contain important information. Welders who can read, understand and use the information in blueprints will avoid many costly mistakes and be more valuable workers.

UNIT OBJECTIVES

After you finish this unit, you will be able to identify the basic lines and views of a print and interpret the information (dimensions and shapes) in the print.

You will also be able to make three-view drawings with complete and proper dimensions and be able to list the steps for making an isometric drawing.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to specifically:

1. Identify the basic lines of a blueprint.
2. Identify the basic views of a blueprint.
3. List the steps in making an isometric sketch.
4. Make a three-view sketch from an isometric drawing.

ARE YOU READY?

CHECK THE STATEMENT THAT IS TRUE FOR YOU:

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms and Equipment Needed

Terms

1. **Blue line or shop drawing** - a drawing with a white background and blue or black lines.

2. **Blueprint** - a print with a blue background and white lines.

3. **Dimension line** - a line that runs between extension lines, has an an arrow on each end and a break in the middle. A number that tells the length, width or depth of the object drawn is placed in the break.

4. **Front view** - a view on a three-view drawing that shows the front of the object drawn.

5. **Extension line** - a line that extends, but does not touch, an object line. The extension line shows what the dimension line is measuring.

6. **Hidden line** - a broken (----) line that shows hard-to-see parts.

7. **Isometric drawing** - a drawing that shows the top, front and end of an object at once, from one viewpoint.

8. **Object line** - a line that represents the outline of an object.

9. **Phantom line** - a line that shows how a part moves.

10. **Cutting plane line** - a line that shows what part of an object will be shown in a sectional view.

11. **Sectional view** - a view on a drawing that shows what the inside of an object would look like if it were cut in half at the spot shown.

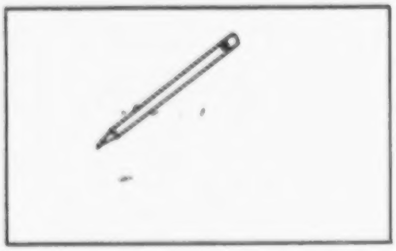
12. **Side view** - a view on a three-view drawing that shows the side of an object.

13. **Top view** - a view on a three-view drawing that shows the top of an object.

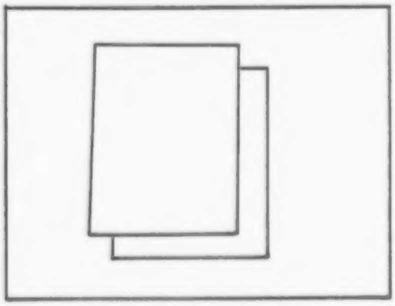
14. **Working view** - a drawing that uses phantom lines to show motion.

Equipment

Pencil



Paper



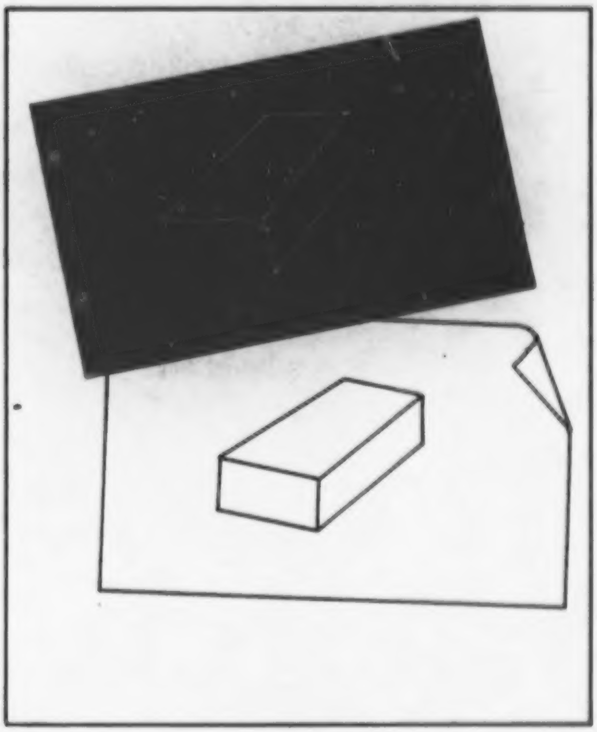
B. Understanding Blueprints

1. Gather your equipment.

2. Before beginning, you need to understand the difference between a blueprint and a blueline drawing (shop drawing or print).

   a. Blueprints have white lines on a blue background. Blueprints are not commonly used in shops because the blue background fades rapidly in sunlight.

   b. Blueline drawings are more common in welding shops. They don't fade like blueprints. Blueline drawings have blue or black lines on a white background.



NOTE: The information shown on a blueprint and a blueline drawing is the same. The difference between the two drawings is in how each is made.

3. Although a blueline drawing doesn't have a blue background, workers often call it a "blueprint" or "print" anyway. Either name is okay if you are talking about a blueline drawing.

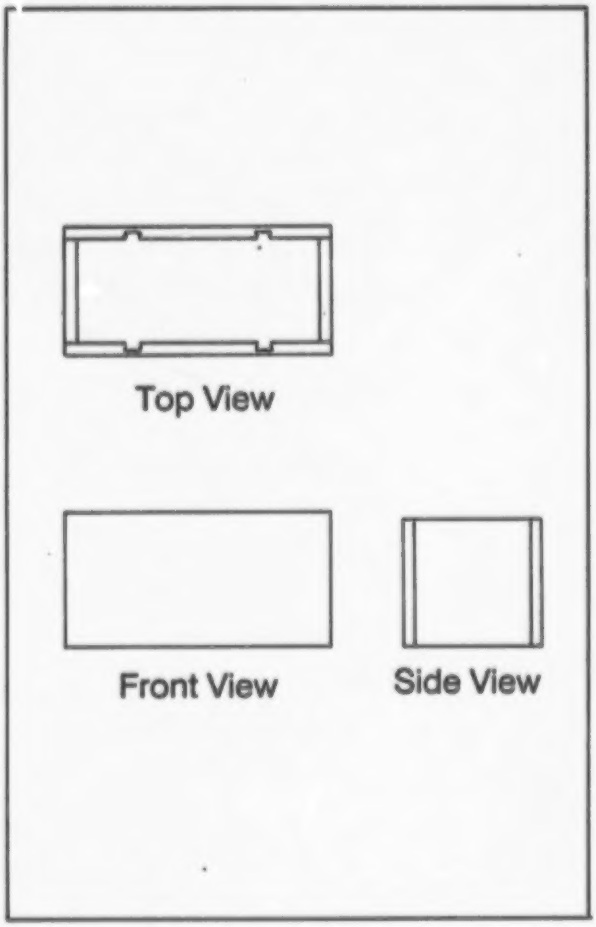
4. Note that the Box in the picture is shown from three different views. These views are the:

   a. Top view--shows how the box would appear if you set the box on the floor and looked down at it.

   b. Front view--shows how the box would appear if you held the side of the box at eye level and looked at the front of it.

   c. Side view--shows how the box would appear if you held the end of the box at eye level and looked at it.

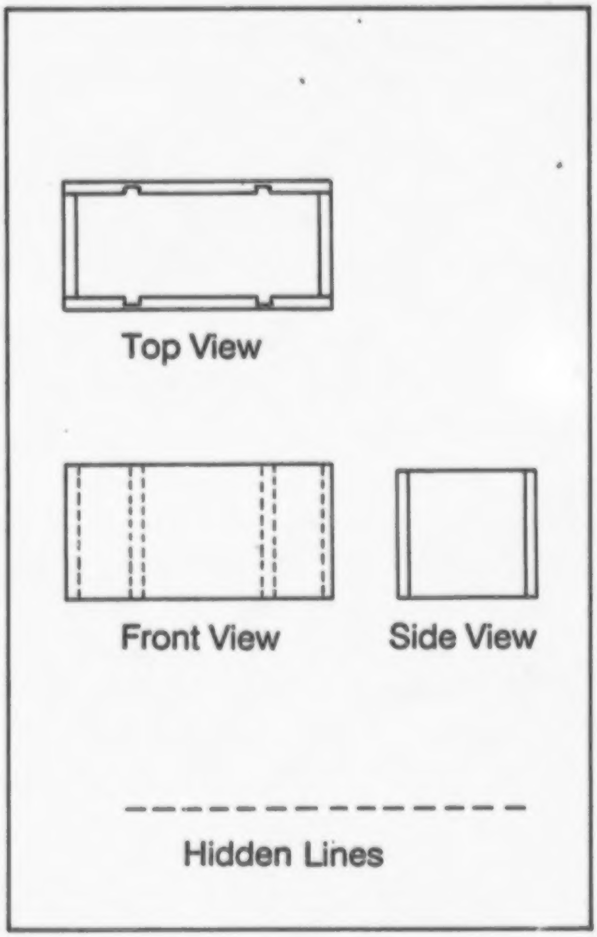
   Three views are shown so the viewer can mentally "see" what the entire object looks like.



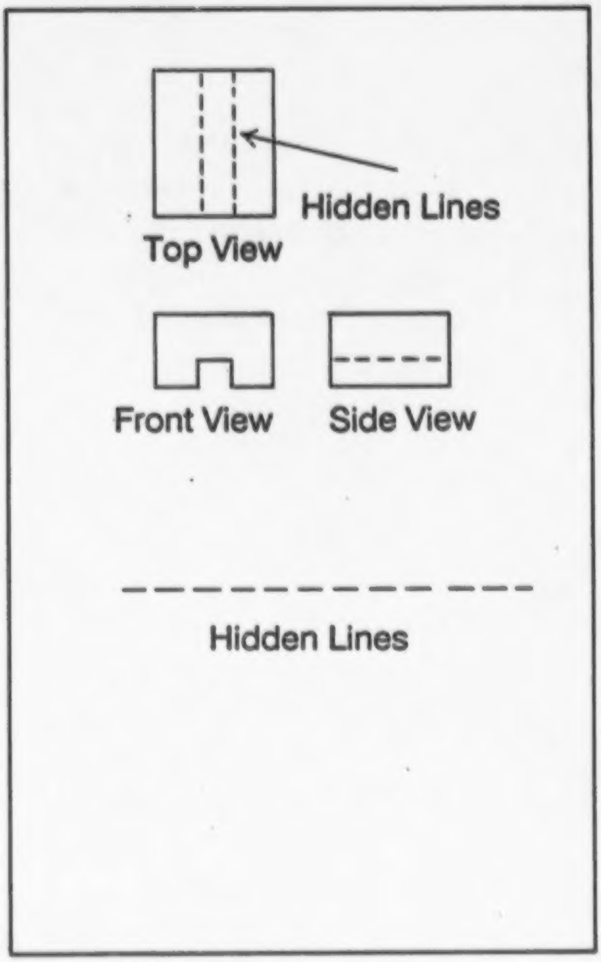
5. The lines that show the actual shape of the box are called **object** lines. By looking at all 3 views, you can see the shape of the entire object.

6. Often it is difficult for the designer to show all parts of an object in three views. In such cases, he/she uses different lines to show the welder which part of the object is out of sight.

   These lines are called **hidden lines**, drawn as short, dashed lines. They represent details not visible from the viewpoint being used.



7. Look at these three different views of the same object.



8. Notice the hidden lines in the top and side views. The hidden lines show details that are not visible from either top or side views.

9. The hidden lines show a groove along the bottom of the box.

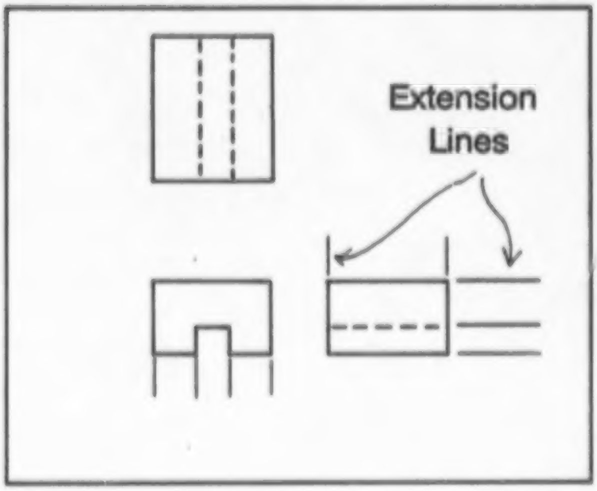
   The top view shows the length and width of the groove; however, the top view cannot show how deep the groove is.

10. To see the depth of the groove, the welder must look at the side view. The welder can also see the length of the groove from this view; however, the width of the groove is not seen from the side.

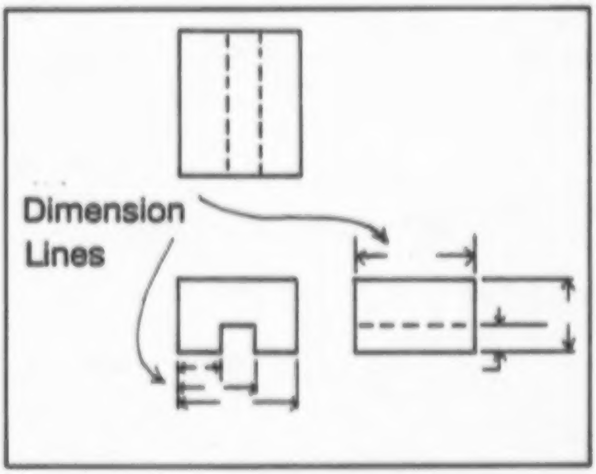
11. Because some details can only be seen in one view of an object, the welder needs all three views to see what the final product should look like.

12. Now look at the extension lines added to the drawing. The extension lines help show the size of the object.

NOTE: Extension lines do not touch the object lines or hidden lines.



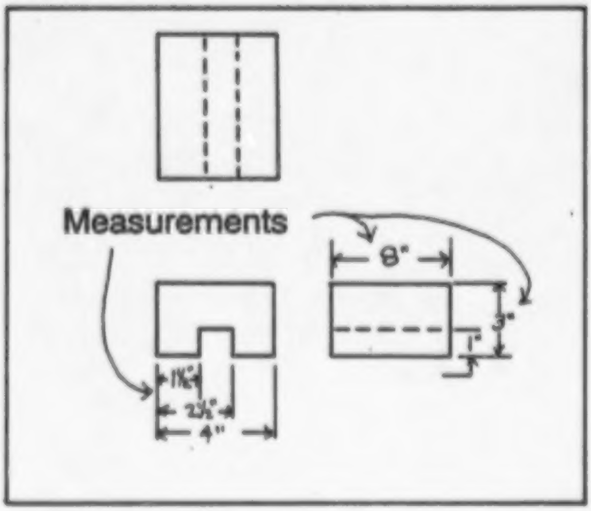
13. Dimension lines are added between the extension lines so measurements are easy to see. Dimension lines have an arrow at each end and a break near the middle in which the precise measurement is placed.



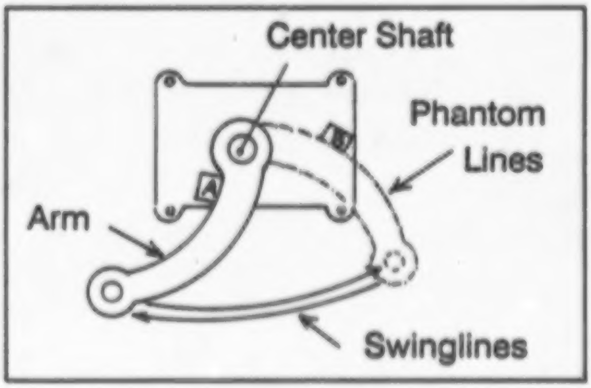
14. The measurements show the exact size of each part to be welded.

    NOTE: The symbol (") is used for inches, and the symbol (') is used for feet. For example:

    8" = 8 inches
    8' = 8 feet


Measurements
8"
3"
1"
1½"
2½"
4"

15. Sometimes parts are not supposed to be welded in place. The parts may need to be left free so they can move or rotate. The way a piece should move is shown on a working drawing through phantom lines.


Center Shaft
Phantom Lines
Arm
A
B
Swinglines

16. In the drawing, see how the arm is left free to rotate on the center shaft until it contacts the stops (parts A and B). Notice the swing lines, which show the direction of travel, at the bottom of the arm.

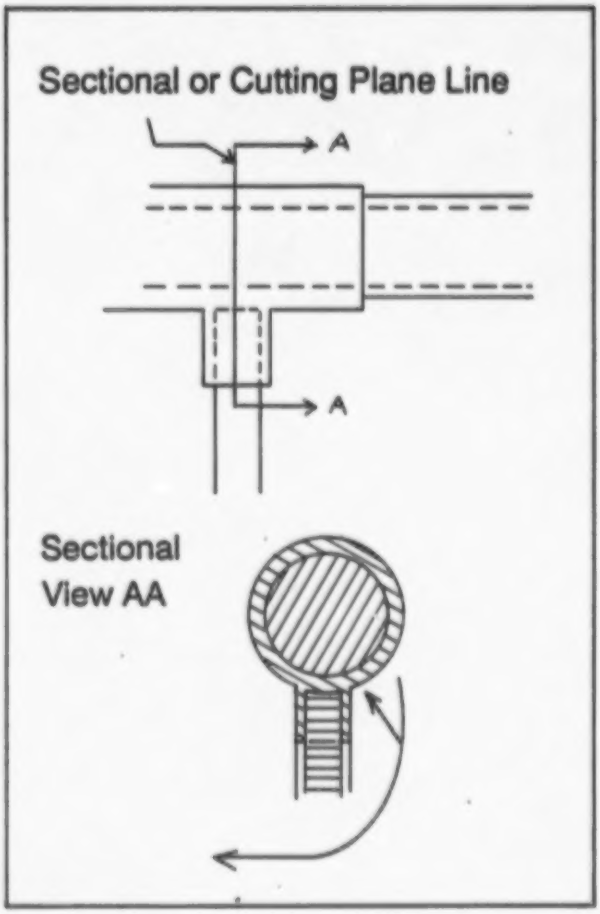
17. Phantom lines are not drawn as darkly as object lines so the welder can tell the two types apart. Remember, phantom lines simply show the movement of a part on a working drawing.

18. The last type of line is the **cutting plane line.** The cutting plane line shows the inside of an object (as if you had cut the object in half and turned it 90°).

19. Cutting plane lines are identified by letters at the end of arrows.

20. Cutting plane lines indicate the exact location of a sectional view.

21. Note the different angles of the lines in the sectional view A-A. The angles show that there are three separate pieces in the sectional view.



Do Skill Sheets 1 and 2

SKILL SHEET 1

Identify the lines and views in the print below. Place your answer in the blanks provided.

A. ________

B. ________

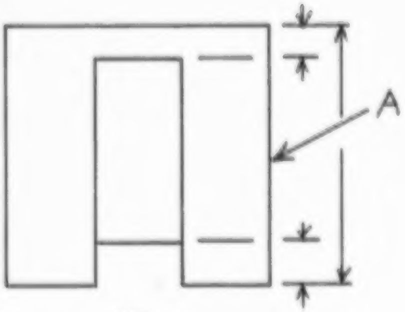
C. ________

D. ________

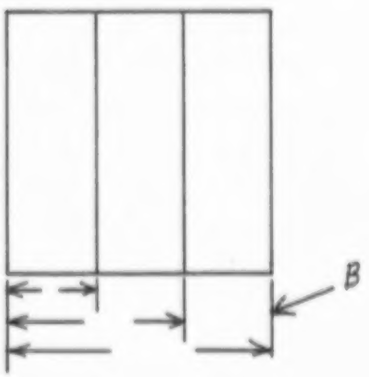
E. ________

F. ________

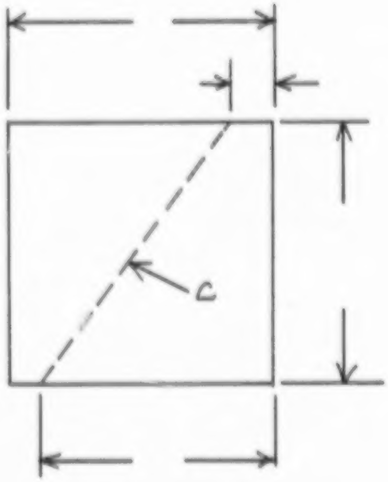
G. ________



E. _____ View



F. _____ View



G. _____ View

SKILL SHEET 2

Identify the views and lines used below. Place your answer in the blanks provided.

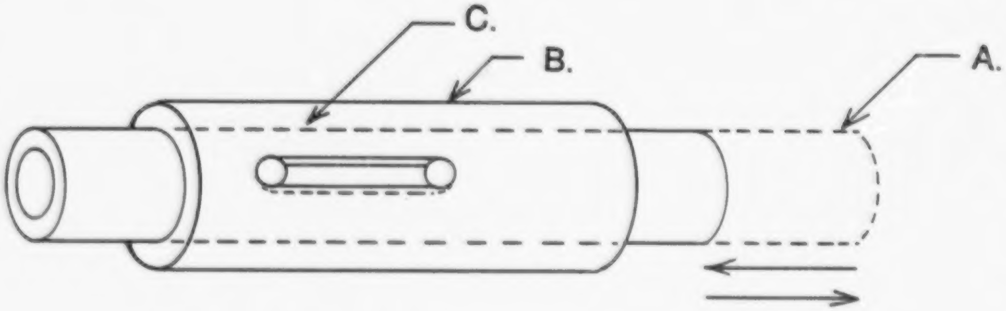
A. ________

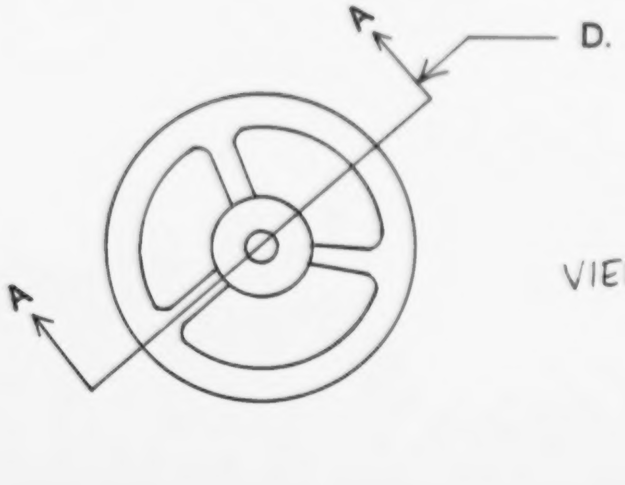
B. ________

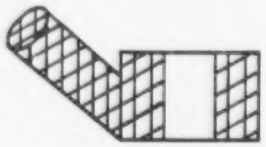
C. ________

D. ________

E. ________







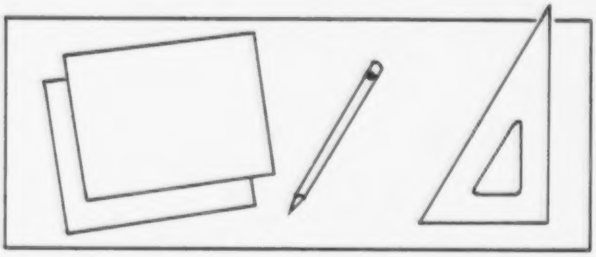
VIEW A-A

E. _____ Type of View

C. Steps of Procedure for Making an Isometric Drawing.

An isometric drawing shows the top, side and front view of an object -- all in the same drawing. The isometric drawing shows how the object will actually appear from a single vantage point and is used to give the viewer a clear idea of its dimensions. The object usually looks as if it is tilted up on its front corner, a position that allows the viewer to see several sides of the object at once.

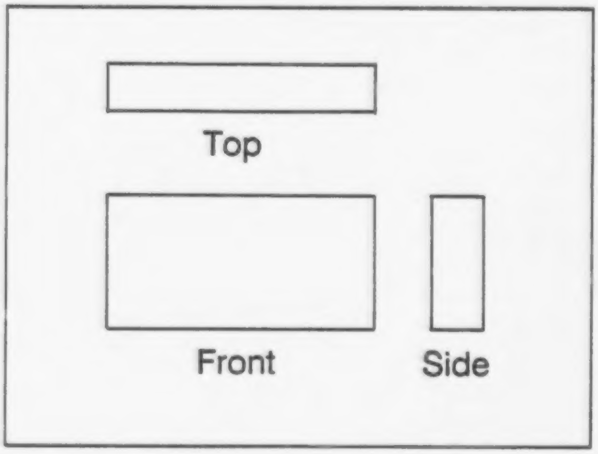
1. In order to make an isometric drawing, the designer uses a few basic drafting tools -- paper, pencil and a 30-60° triangle.



2. Let's study the steps a designer would follow to make an isometric drawing from the three-view drawing at the right.

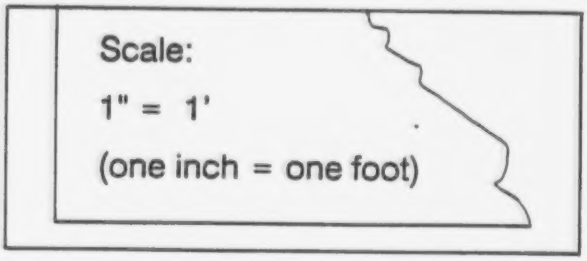
   Note: This three-view drawing represents a real-life object. Because the page isn't big enough to draw the box exactly as it appears in real life, the drawing has been made "to scale."

   Making a drawing "to scale" means the lines in the drawing are in proportion with the actual dimensions of the object.



For example, after measuring lines in a drawing with a ruler, you find that one side of the drawn box is one inch long.

The scale given says an inch in the drawing equals a foot in real life, which means the side should be one foot long when you finish building the box.



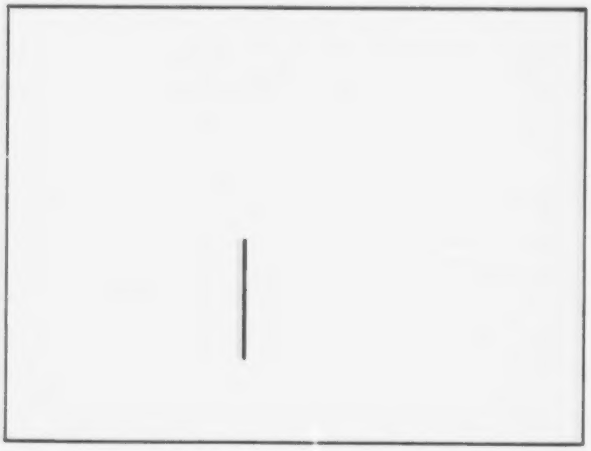
Scale:

1" = 1'

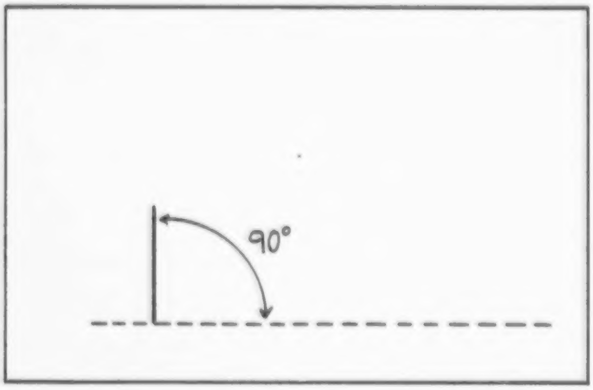
(one inch = one foot)

3. The designer draws the vertical (up and down) corner line first. He or she makes the line match the length of the vertical lines in the three-way drawing.

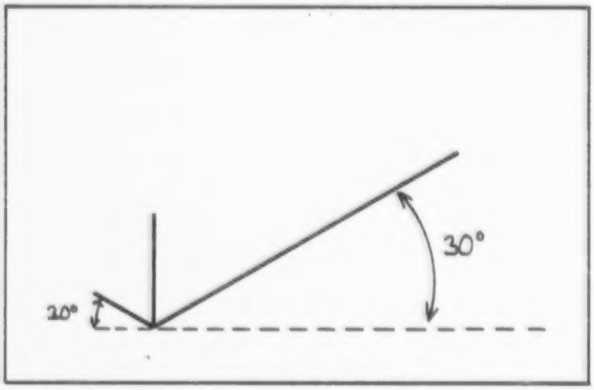
(If the designer wants the isometric drawing to be a different size than the three-view drawing, he or she must enlarge or shrink the "scale" of the drawing.)



4. Then the designer draws a horizontal (side to side) line at a 90° angle to the vertical line.

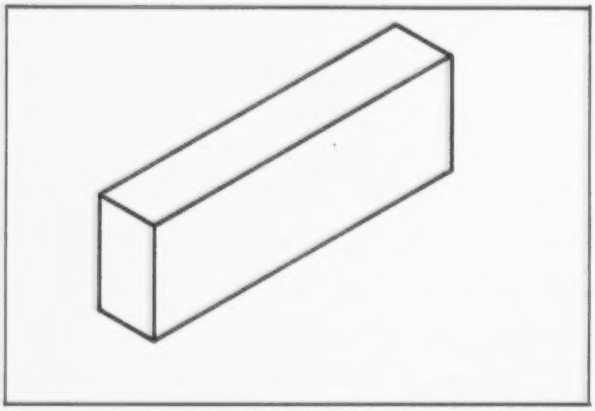


5. Next the designer draws two lines at a 30° angle above the horizontal line. He or she makes one line equal to the length of the object and another line equal to the width.



6. Finally, the designer draws the other edges of the object. He or she makes the lines parallel and equal in length to the lines already drawn.

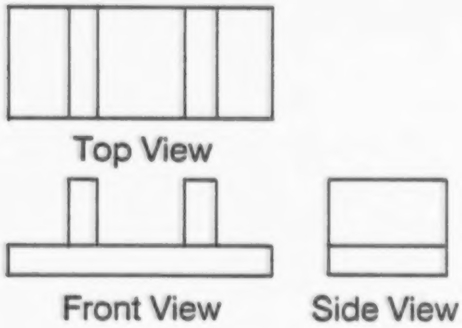
7. The designer has now created an isometric drawing from the original three-view drawing.



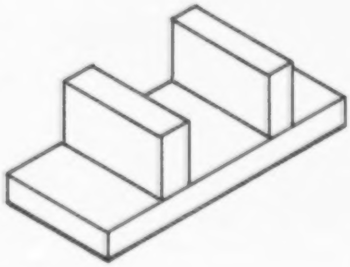
Do Skill Sheet 3

SKILL SHEET 3

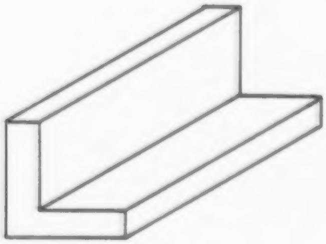
Study the isometric drawings at the right. Make a three-view drawing of each object. The first one has been done for you as an example.


Top View
Front View
Side View

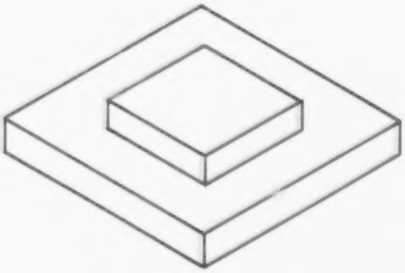
1.



2.



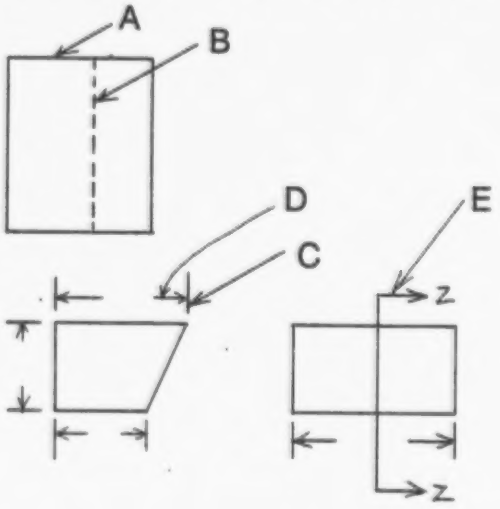
3.



BLUEPRINT READING: BASIC VIEWS

UNIT REVIEW

1. Identify the lines in the drawing below.



A. ________

B. ________

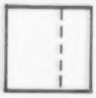
C. ________

D. ________

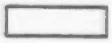
E. ________

2. Identify the views in the drawing below.

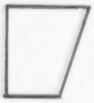
A.



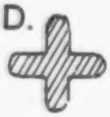
C.



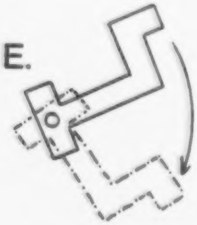
B.



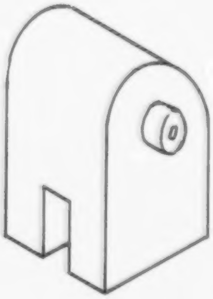
D.



E.



F.



A. ________

B. ________

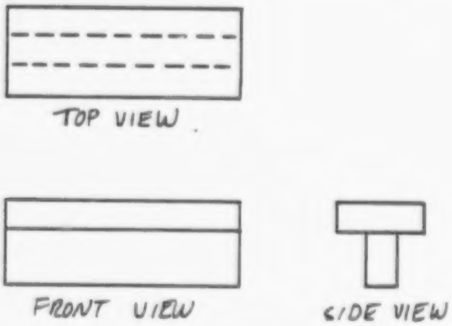
C. ________

D. ________

E. ________

F. ________

3. Study the three-view drawing below. List the steps for making an isometric drawing from a three-view drawing.


TOP VIEW
FRONT VIEW
SIDE VIEW

PERFORMANCE CHECKLIST

Student ________________ successfully performed the following tasks:

	Yes	No	Comments
1. Identified basic lines of a print			
2. Identified basic views of a print			
3. Told how to make a basic isometric sketch from a print			
4. Made a three-view sketch from an isometric drawing			

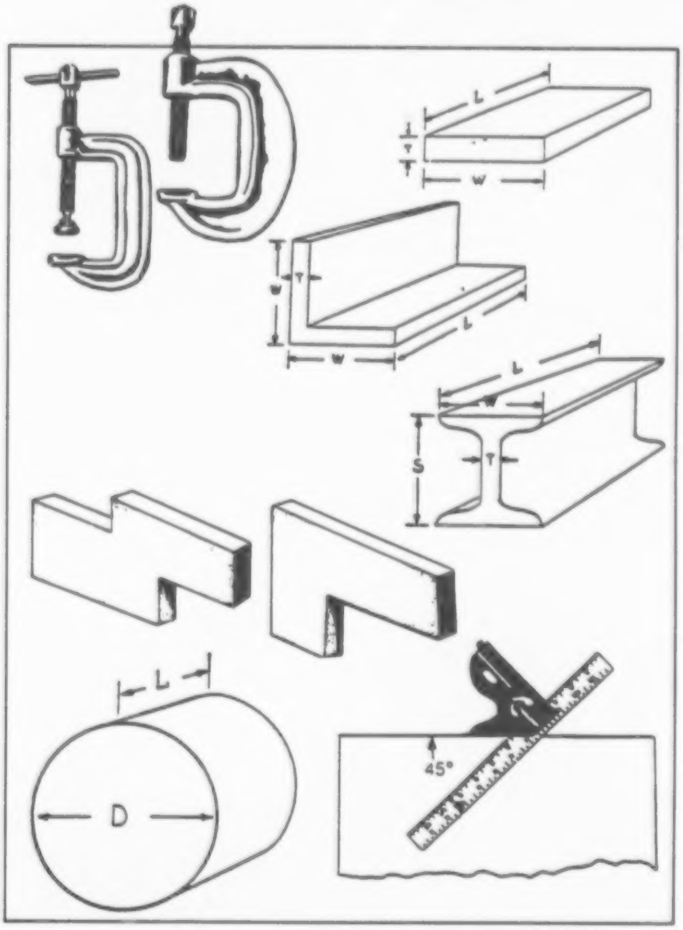
☐ Satisfactory-should move on

☐ Should repeat this unit

Student's Signature/Date

Instructor's Signature/Date

WELDING Supplementary Units


L
T
W
L
T
W
L
W
L
W
S
T
L
D
45°

Blueprint Reading
Welding Symbols
and
Abbreviations

BLUE PRINT READING: WELDING SYMBOLS AND ABBREVIATIONS

INTRODUCTION

Welders use blueprints to see how pieces fit together to make a finished product. Often parts must be welded at specific places and have specific sizes and strengths. The design engineer puts this information, in symbols and abbreviations, on the print. To do what the designer wants, the welder must understand these symbols and abbreviations.

The American Welding Society has created a set of universal symbols that give the welder information about a weld. The symbols use few words so that the print is less "cluttered" and easier to understand.

Welders can read blueprints if they understand the basic welding symbols.

UNIT OBJECTIVE

After completing this unit, you will be able to identify and understand the welding symbols and abbreviations on a blueprint.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to specifically:

1. Identify and correctly use welding symbols.
2. Identify and correctly use abbreviations when making decisions about welds.

ARE YOU READY?

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms and Equipment for Welding Symbols and Abbreviations

1. **Arrow** - a point attached to the reference line. It points to the spot where work called for on the reference line is to be done.

2. **Arrow side** - the side of the weld joint to which the arrow points.

3. **Backing symbol** - a symbol that means a backing strip or back up plate should be used when making a weld.

4. **Build up** - to make a piece thicker by welding on it.

5. **Chain intermittent** - an intermittent weld in which the weld beads align on each side of the plates.

6. **Concave** - a weld face that is rounded inward, as on the inner surface of a hollow ball.

7. **Contour** - a term that describes the finished appearance of a weld. (The three different weld contours are concave, convex and flush.)

8. **Convex** - a weld face that is rounded outward, as on the outer surface of a ball.

9. **Field weld symbol** - a symbol that means the weld will be made at the final assembly point.

10. **Fillet weld** - a weld that joins two pieces of metal together at right angles. It can be used with lap, tee or corner joints.

11. **Flush** - a flat weld face.

12. **Leg of weld** - in a fillet weld, the "leg" refers to the distance from the root of the joint to the toe of the weld.

13. **Length** - the distance of a weld from its starting point to its finish.

14. **Melt thru** - a symbol that tells a welder to burn or melt thru the metal being welded.

15. **Otherside** - the opposite side of the weld joint from the side the arrow points to.

16. **Pitch** - the distance from the center of one intermittent weld to the center of the next intermittent weld.

17. **Reference line** - a line used in blueprints to list symbols for the welder's information.

18. **Staggered intermittent** - an intermittent weld where the weld beads do not align equally on each side of the plates.

19. **Tail** - the area at the end of a reference line. The tail is used to add more information about the weld.

20. **"Toe" of the Weld** - the portion of the weld where the bead and base metal meet.

21. **Weld-all-around symbol** - a symbol that means the weld goes all the way around the joint.

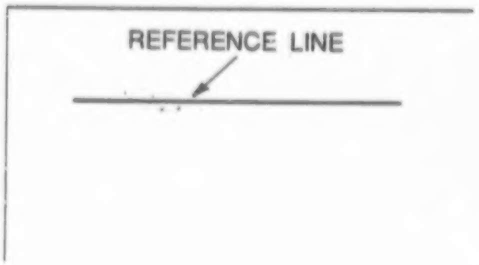
Equipment

Blueprint
Pencil
Paper

B. Understanding Welding Symbols

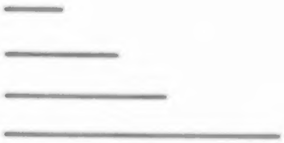
1. Gather your equipment and put it together.

2. When using blueprint symbols, the reference line is the starting point for all information.

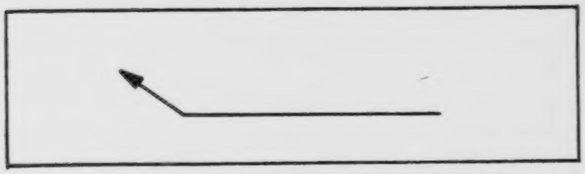


   If you are viewing a blueprint correctly (right side up), the reference line is horizontal. Reference lines should always be horizontal.

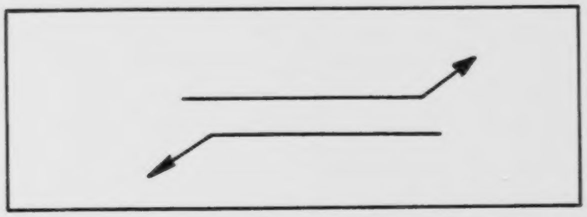
3. Reference lines can be any length, but they should not be overly long. They need to be long enough for the needed information, but no longer.



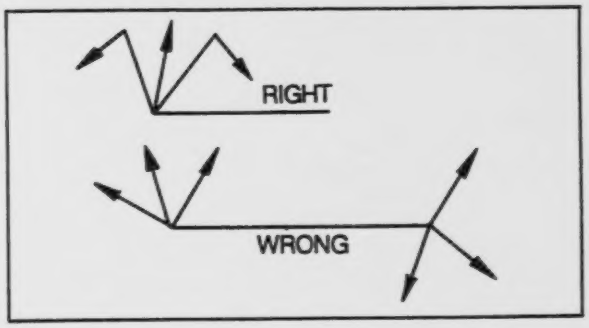
4. An arrow is attached to the reference line. The arrow tells the welder where to put the weld.



The arrow can come from the right or left end of the reference line and can point up, down, left or right.

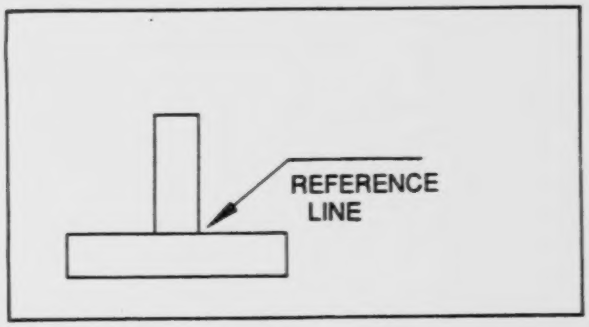


5. A reference line can have more than one arrow, but the arrows should attach to only one end of the line.

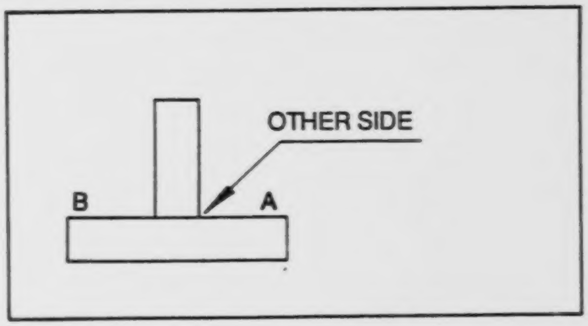


6. The reference line and arrow, used together, can also show the welder where to place the weld.

- When information is placed above the reference line, the weld should be placed on the other side of the joint.

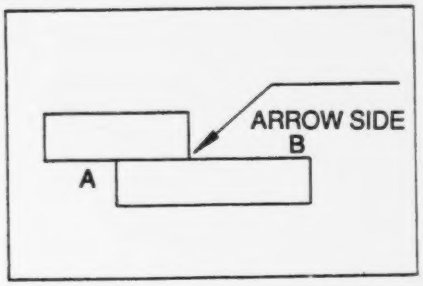


- When information is placed below the reference line, the weld should be placed on the arrowside of the joint.



In the first example, the weld should be made on side B. In the second (top of next page), the weld should be made on side A.

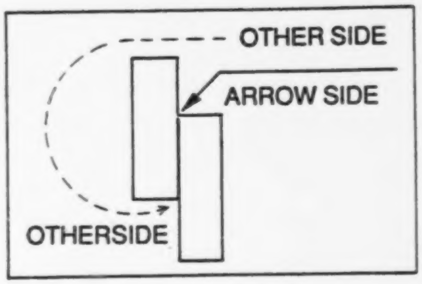
7. Look at the following examples to be sure you understand "arrowside" and "other side."

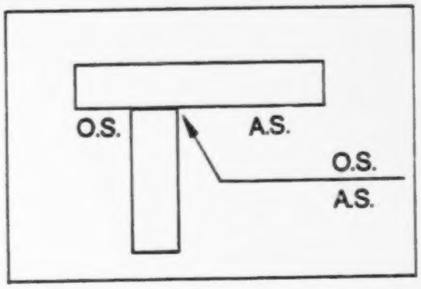

ARROW SIDE
B
A

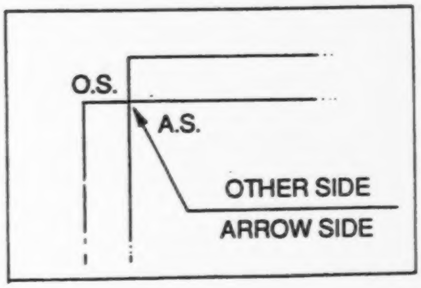
8. Let's review:

    - If the information is above the reference line, the weld should be placed on the "otherside." The otherside is the side the arrow does not point to.

    - If the information is below the reference line, the weld should be placed on the "arrowside." The arrowside is the side the arrowhead points to.


OTHER SIDE
ARROW SIDE
OTHERSIDE



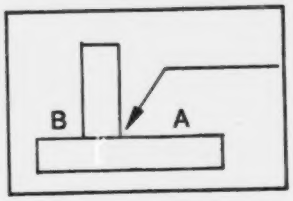

O.S.
A.S.
OTHER SIDE
ARROW SIDE

Do Skill Sheet 1.

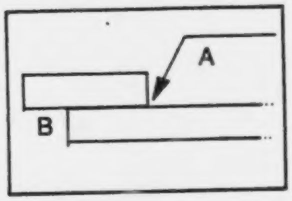
SKILL SHEET 1

Use the letter "A" to identify the arrow side and the letter "B" to identify the other side. Place your answers on the lines provided. Number one has been done to show you how.

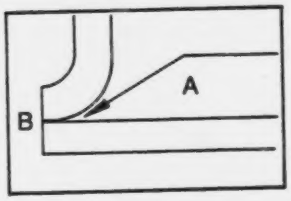
1. Arrow side A
Otherside B



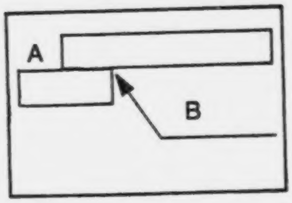
2. Arrow side ____
Otherside ____



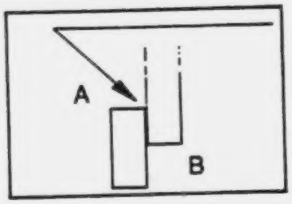
3. Arrow side ____
Otherside ____



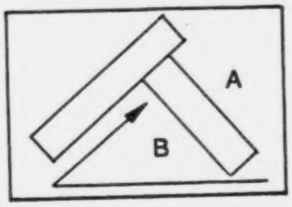
4. Arrow side ____
Otherside ____



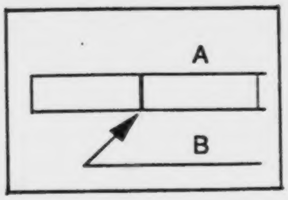
5. Arrow side ____
Otherside ____



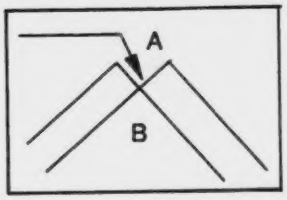
6. Arrow side ____
Otherside ____



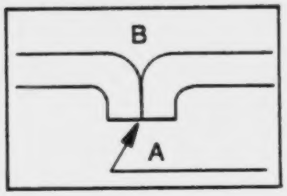
7. Arrow side ____
Otherside ____



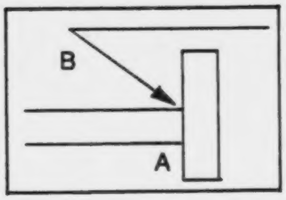
8. Arrow side ____
Otherside ____



9. Arrow side ____
Otherside ____

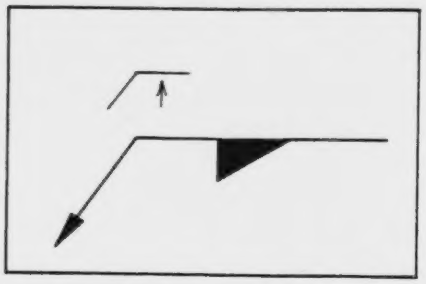


10. Arrow side ____
Otherside ____

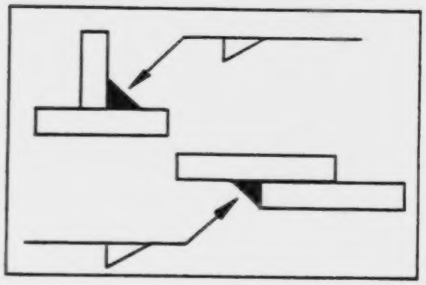


C. Using fillet weld symbols and information

1. Symbols are used above or below the reference line to give the welder important information. One of the most common symbols is the "fillet weld."



2. The "fillet weld" symbol first moves upward at a right angle to the line, slants to the right and goes back to the reference line.

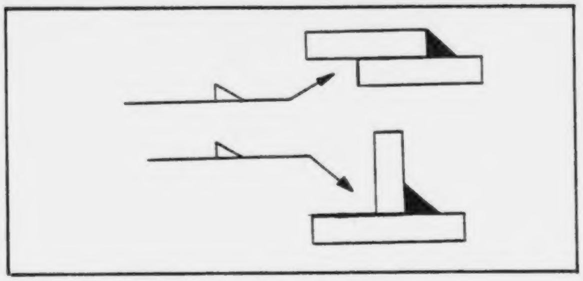


3. On its way back to the reference line, the fillet weld's line should always slant to the right, never to the left.

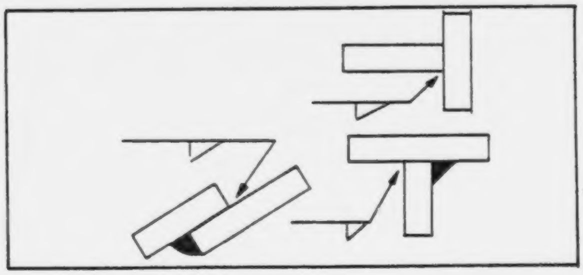
4. Notice that, in this example, the fillet weld symbol is below the reference line.

5. Since the symbol is below the reference line, the arrow side of the joint is to be welded.

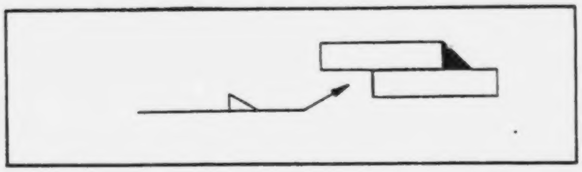
6. If the fillet weld symbol were above the reference line, the other side of the joint would be fillet welded.



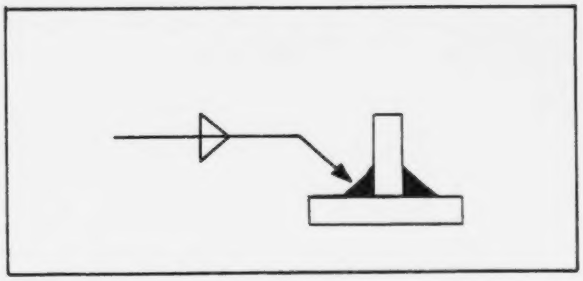
7. Remember: If a symbol is below the reference line, the weld is placed on the arrowside of the joint.



If a symbol is above the reference line, the weld is placed on the otherside of the joint.

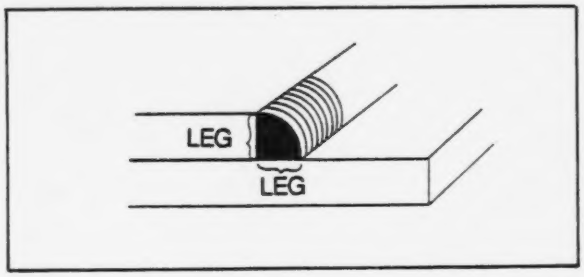


8. Sometimes a designer wants a weld on both sides of a joint. If so, he or she puts a symbol both above and below the reference line.

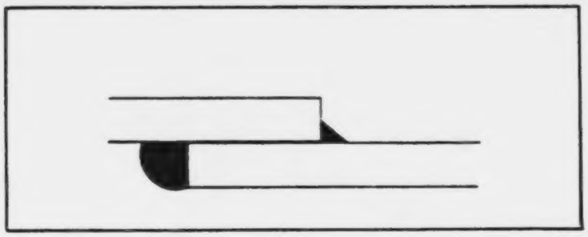


9. The size of a fillet weld is determined by the length of the weld's legs.

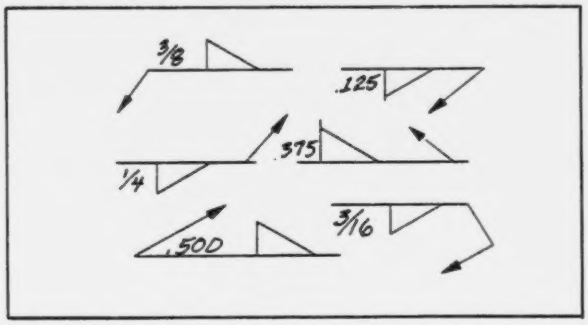
10. The "leg" of a fillet weld is the part between the root of the joint and the toe of the weld.



11. Sometimes the designer wants the finished fillet weld to be a specific size. If so, the designer puts more information on the weld symbol.

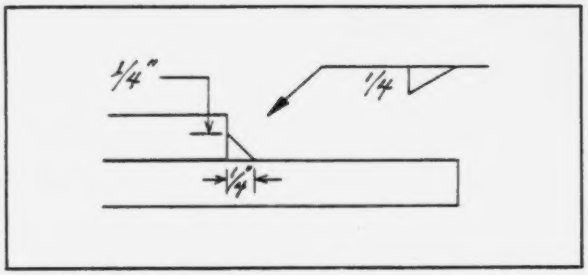


12. The designer puts the desired fillet weld size in front (to the left) of the fillet weld symbol in the form of a decimal or fraction.

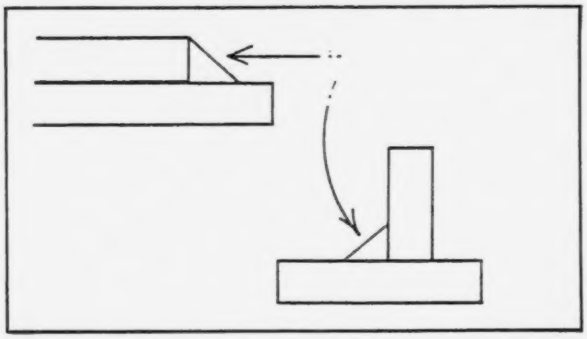


13. The decimal or fraction tells the welder what size the fillet weld should be.

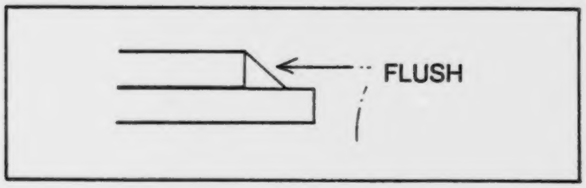
14. If the plan calls for a quarter-inch fillet, each of the legs should be 1/4 of an inch long.



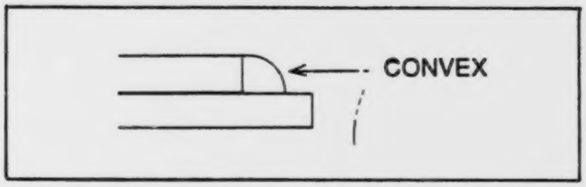
15. The designer may also want the finished weld to have a specific contour. "Contour" refers to the shape of the weld's face. The "face" is the part of the bead that can be seen after the weld is made.



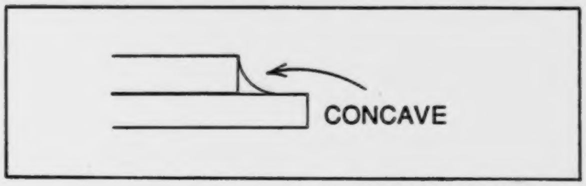
16. The designer may want the face of the weld to be flat, or flush.



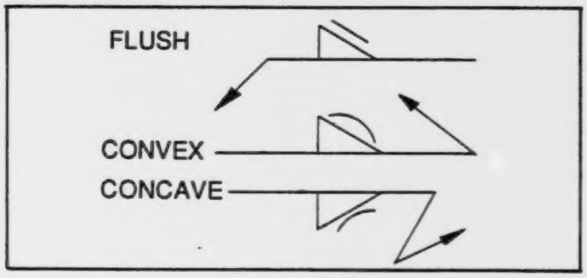
17. The designer may want the face of the weld to be convex (rounded out).



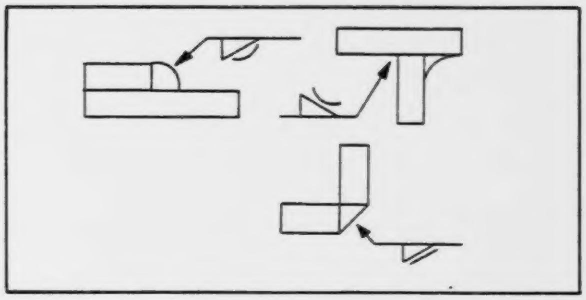
18. Or the designer may want the face of the weld to be concave (rounded in).



19. Information on the contour of the weld face can be found in the weld symbol above the slanted line.



20. Look at the examples. If you notice that each contour symbol looks like the weld face it represents, it may help you remember which symbol goes with each type of contour.



Do Skill Sheet 2

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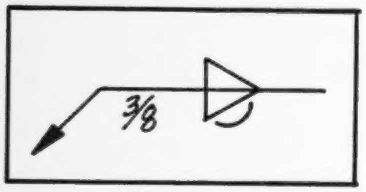
SKILL SHEET #2

Read the welding symbols below. Write the information the symbols give. The first problem has been done to show you how.

Example Symbol

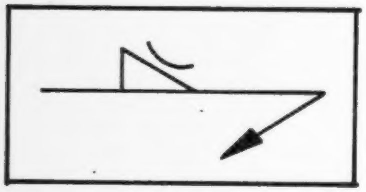
1.



Arrowside
1. fillet weld
2. 3/8" leg length
3. convex contour

Otherside
1. Fillet weld

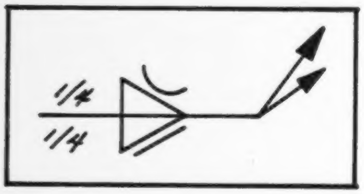
2.



Arrowside

Otherside

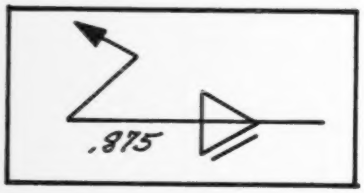
3.



Arrowside

Otherside

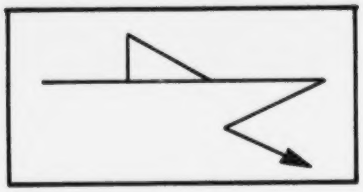
4.



Arrowside

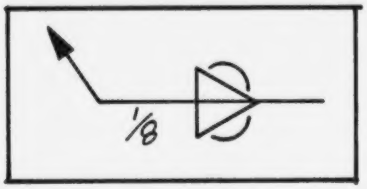
Otherside

5.



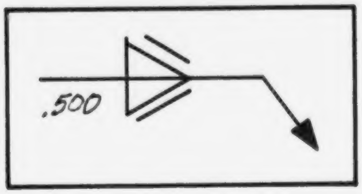
Arrowside Otherside

6.



Arrowside Otherside

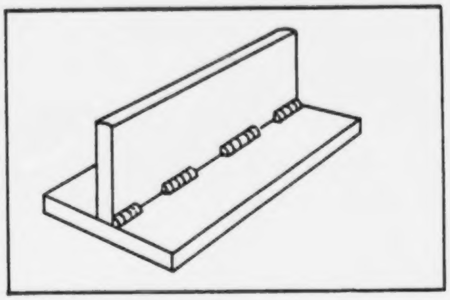
7.



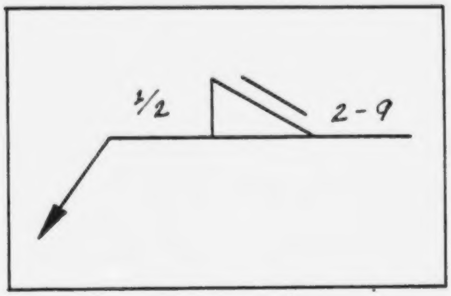
Arrowside Otherside

D. Using Intermittent Weld Symbols

1. Often a designer asks for an "intermittent" weld. In other words, the designer wants the welder to fuse two pieces of metal together with a series of short welds that do not touch each other.



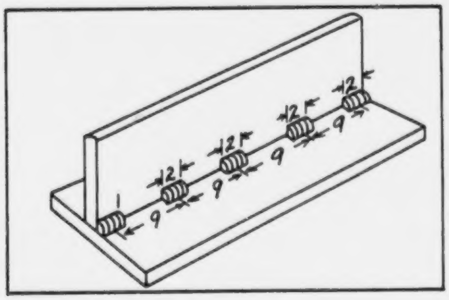
2. To ask for such a weld, the designer places a series of numbers to the right of the weld symbol.



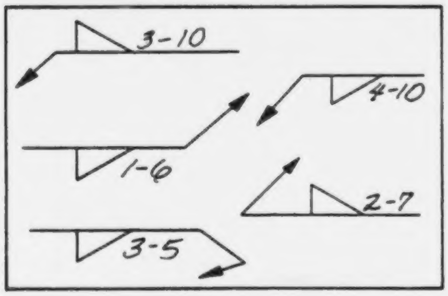
3. The first number gives the length of each intermittent weld in inches. In the example to the right, each intermittent weld should be 2 inches long.

4. The second number indicates the pitch. Pitch is the distance from the center of one intermittent weld to the center of the next. In the example to the right, the pitch is 9 inches.

5. In the example to the right, the weld length is 2 inches. The pitch (distance from the center of one intermittent weld to the center of the next.) is 9 inches.

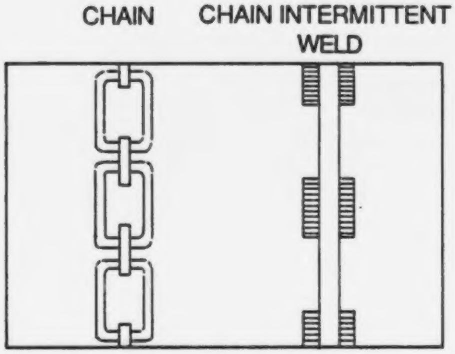


6. The length and pitch can be any length as long as the weld length is not larger than the pitch.

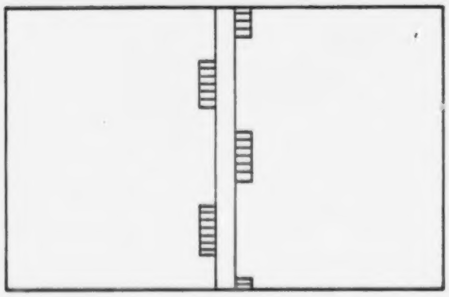


7. When both sides of the joint are welded intermittently, the welds can be called either "chain" intermittent or "staggered" intermittent.

8. In a chain intermittent weld, the welds on one side of the joint are placed directly across from the welds on the other side. The welds look like a chain when viewed from the side.



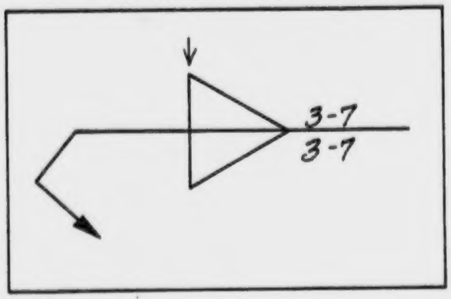
9. In a staggered intermittent weld, the welds on one side of the joint are not directly across from the welds on the other side.



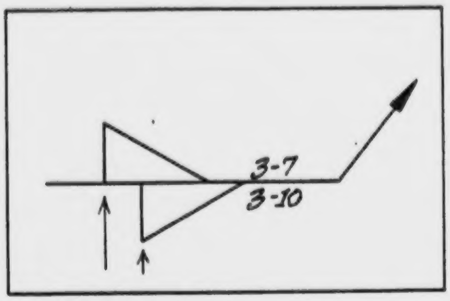
10. If the weld is to be a chain intermittent weld:

- the length and pitch must be the same;
- the fillet weld symbols must align.

ALIGN TOP & BOTTOM

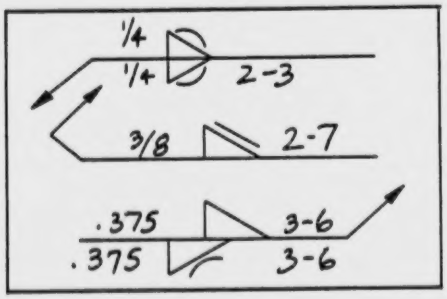


11. If the weld is to be a staggered intermittent weld, the length and pitch do not have to be the same on both sides of the weld.



DO NOT ALIGN

Now you should be able to read these symbols.

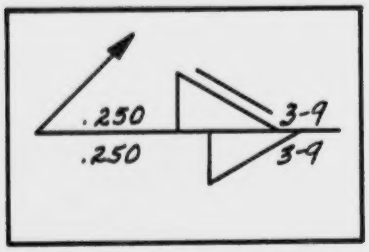


Do Skill Sheet 3.

SKILL SHEET #3

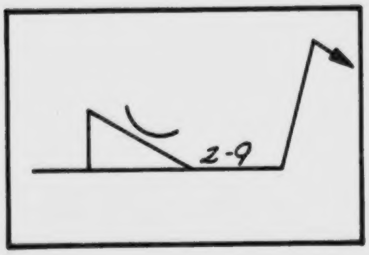
Read the following symbols. List the information under the side that the information applies to. Problem number one has been done to show you how.

1.



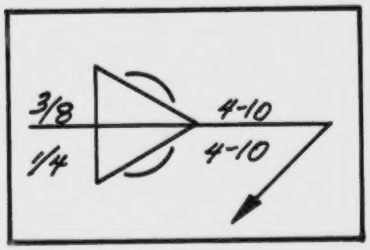
Arrowside	Otherside
fillet weld	fillet weld
flat contour	.250" legs
.250" legs	staggered
3" long staggered intermittent welds	intermittent welds 3" long
9" from center to center	9" from center to center

2.



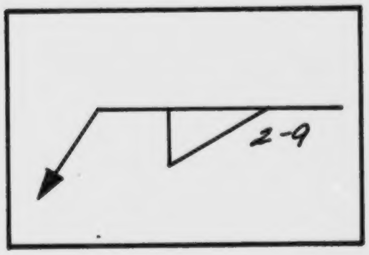
Arrowside	Otherside

3.


3/8
1/4
4-10
4-10

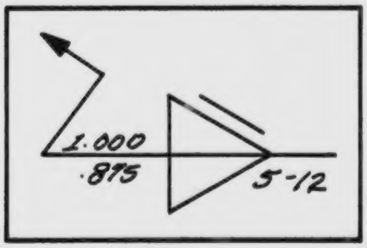
Arrowside Otherside

4.



Arrowside Otherside

5.

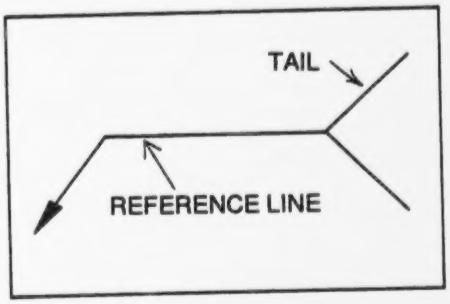

1.000
.875
5-12

Arrowside Otherside

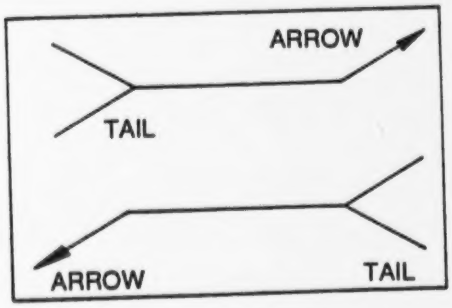
E. Working With Additional Information

1. If the designer needs to add more information than will fit on the reference line, he or she adds a "tail."

2. The tail goes at the end of the line that does not have the arrow.



3. The tail carries additional information. Abbreviations are used to keep the weld symbol neat and uncluttered.



4. Here is a list of abbreviations often found on the tail:

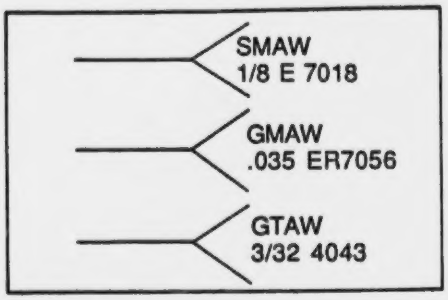
OAW - Oxyacetylene welding
OAC - Oxyacetylene cutting
SMAW - Shielded Metal Arc Welding
GMAW - Gas Metal Arc Welding
GTAW - Gas Tungsten Arc Welding
PAW - Plasma Arc Welding
SAW - Submerged Arc Welding
AAC - Air Carbon Arc Cutting
PAC - Plasma Arc Cutting
TYP - Typical (weld commonly used on print)
Rev# - Revision # (See Revision Block on print)
Note# - See Note# on print for further information)

5. Electrode types and sizes can also be listed on the tail. For example:

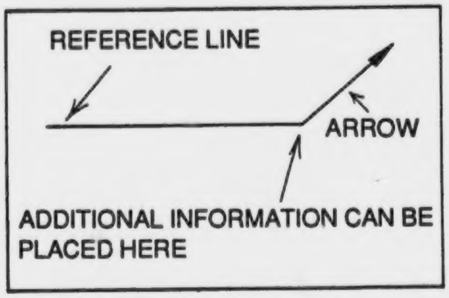
   a. GTAW
   3/32 4043

   b. GMAW
   035 ER7056

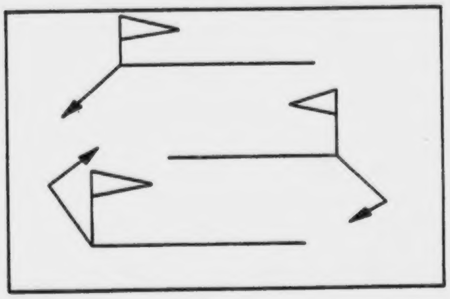
   c. SMAW
   1/8 E7018


SMAW
1/8 E 7018
GMAW
.035 ER7056
GTAW
3/32 4043

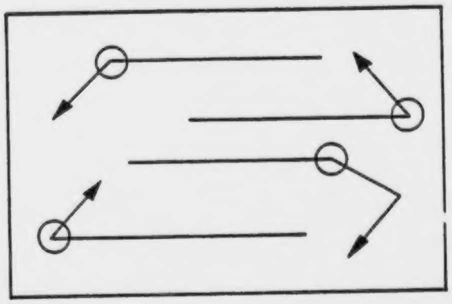
6. Sometimes two important symbols are put where the reference line and arrow meet--the field weld symbol and the weld-all-around symbol.


REFERENCE LINE
ARROW
ADDITIONAL INFORMATION CAN BE PLACED HERE

7. The field weld symbol lies at the top of the reference line and looks like a flag on a pole. The flag always points toward the reference line.

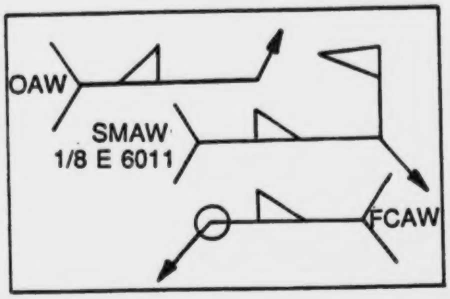


   A field weld symbol means the marked weld will be made at the place of final assembly. This place is usually somewhere other than the shop and is often a construction site.



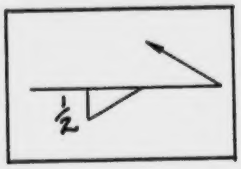
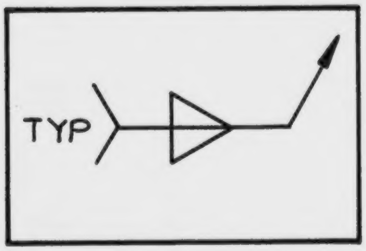
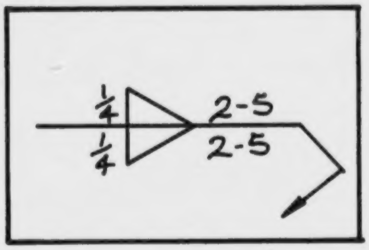
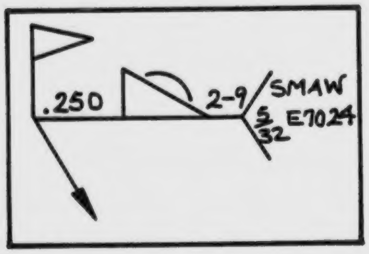
8. The weld-all-around symbol is a circle, located where the arrow and reference line meet. The symbol tells the welder to weld all the way around the joint shown.

9. You should now be able to read each of these welding symbols.


OAW
SMAW
1/8 E 6011
FCAW

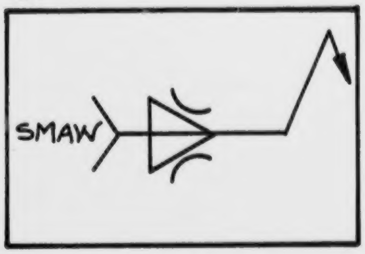
Unit Review

Study the following symbols. Place the information in the correct column. Number one has been done to show you how.

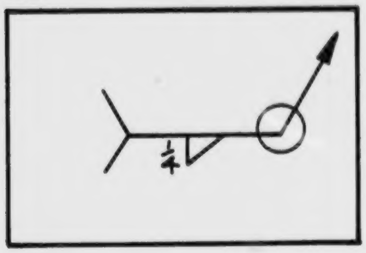
Info.	Arrow side	Other side	Additional Reference Information
1. 	Fillet weld legs 1/2"long		
2. 			
3. 			
4.  .250 2-9 SMAW 5/32 E7024			

Arrow side Other side Additional Reference Information

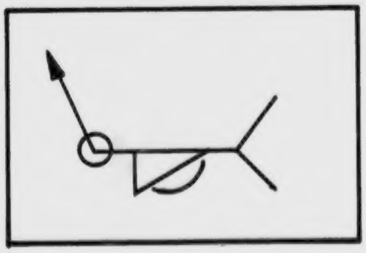
5.



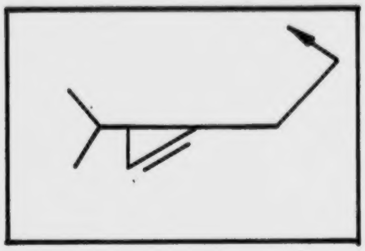
6.



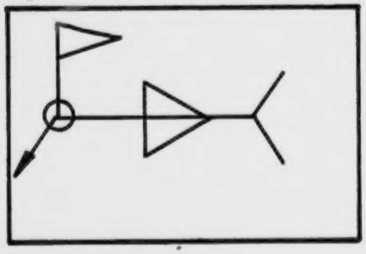
7.



8.



9.



PERFORMANCE CHECKLIST

Student successfully performed the following tasks:

	Yes	No	Comments
1. Identified welding symbols			
2. Used welding symbols correctly			
3. Identified welding abbreviations			
4. Used abbreviations correctly			

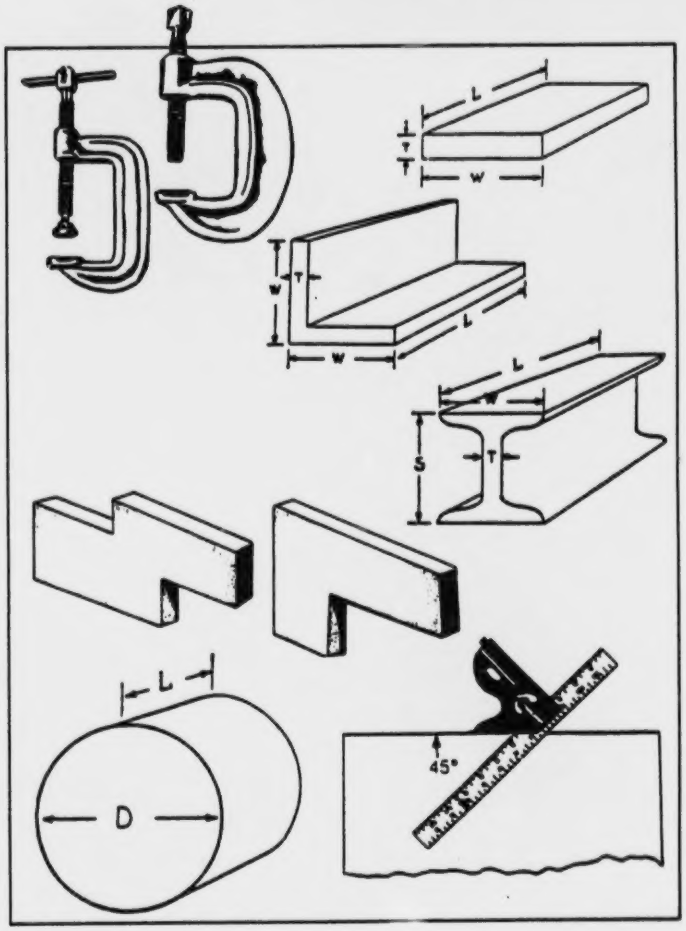
Satisfactory - should move on ☐

Should repeat this unit ☐

Student's Signature/Date

Instructor's Signature/Date

WELDING Supplementary Units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Joint Design
and
Structural
Shapes

JOINT DESIGN AND STRUCTURAL SHAPES

INTRODUCTION

Each time two pieces of metal are welded together, the welder must either design a joint or construct one from information given in a print.

In order to communicate with co-workers and supervisors, the welder must know how to:

- identify each type of weld joint,
- select the best type to use, and
- recognize differences in shape and size between common structural metals.

UNIT OBJECTIVES

When you finish this unit, you will be able to identify the basic types of weld joints, list factors to consider when selecting which joint to use, identify the common structural metal shapes and explain how to size each shape.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to specifically:

1. Identify the five basic joint designs.
2. List factors to consider when selecting a weld joint.
3. Identify angles, channels, beams, flats, strips, plates, sheets, pipes and rounds.
4. Write correct specifications for structural metal shapes.

ARE YOU READY?

CHECK THE STATEMENT THAT IS TRUE FOR YOU:

☐ **I can do these tasks and want to go through the Performance Checklist.**

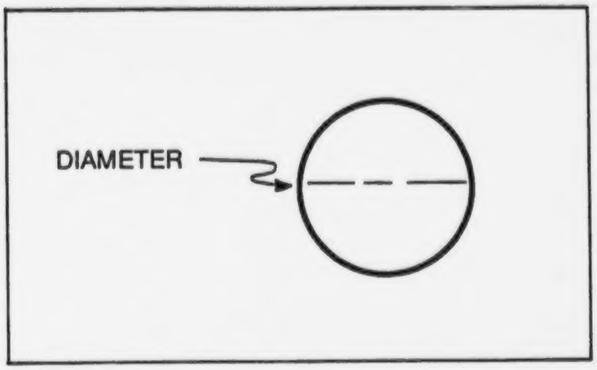
SEE YOUR INSTRUCTOR

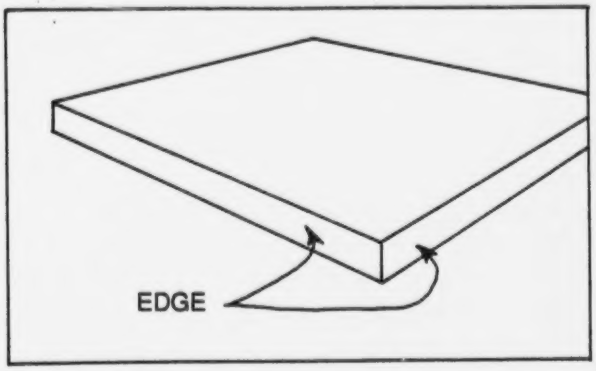
☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

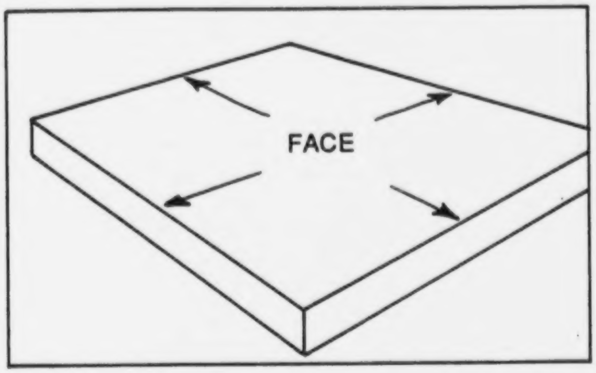
A. Terms Related to Joint Design and Structural Shapes

1. **Diameter** - a measure of the distance across a circle. The diameter is found by drawing, through the circle's center, a straight line segment that begins and ends at the circle's boundary.





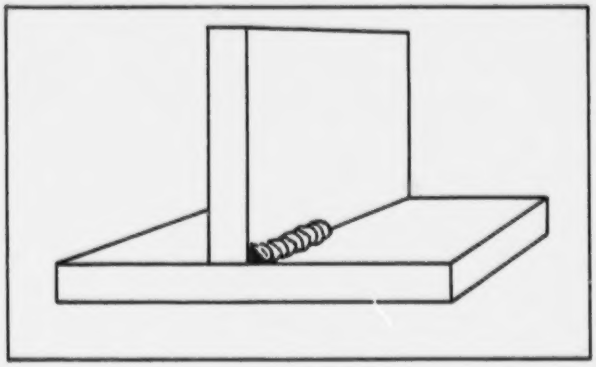
2. **Edge** - the side of a piece of metal.



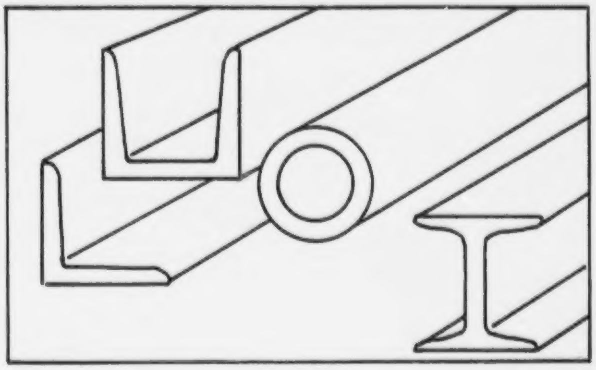
3. **Face** - the widest surface on a piece of metal.

4. **Flange** - the rims that project outward from the ends of "S" or "I" beams.

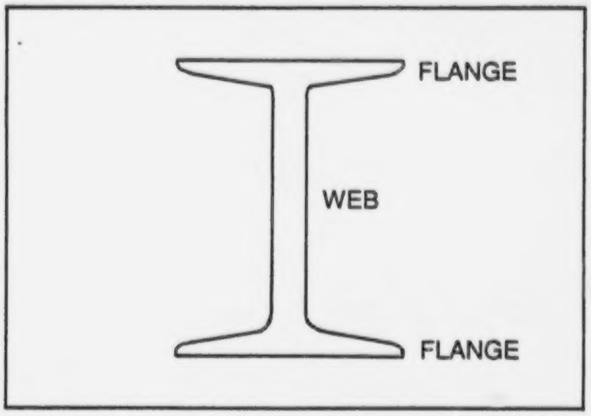
5. **Joint** - the point where two metal surfaces meet. (This is where the weld is placed.)



6. **Structural metal** - a metal that has been pre-formed into shapes for use in constructing buildings, bridges and other projects.



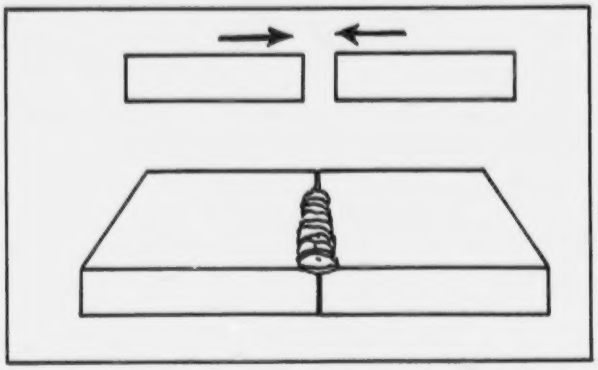
7. **Web** - the "extender" or main portion of an "I" or "S" beam. If a beam is standing on end, the web is the section of the beam that rises and connects to the flanges at top and bottom.



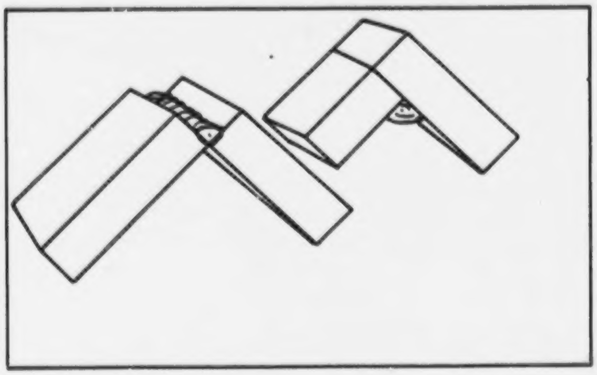
B. Identifying the Five Basic Weld Joints

There are five basic weld joints you will use daily. You must be able to correctly identify each type of joint so that you can communicate with co-workers and supervisors.

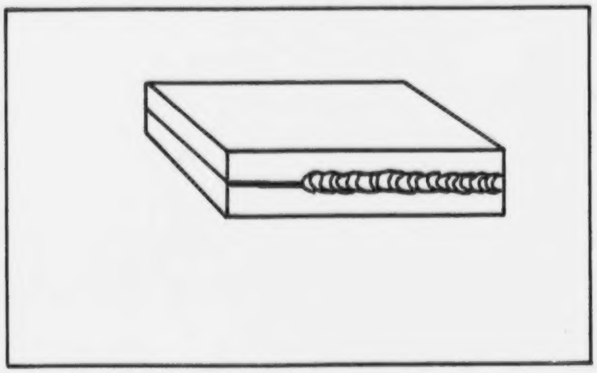
1. A **butt joint** is formed when pieces of metal are welded "edge-to-edge." The weld is made on the metal's face, where the two edges meet.



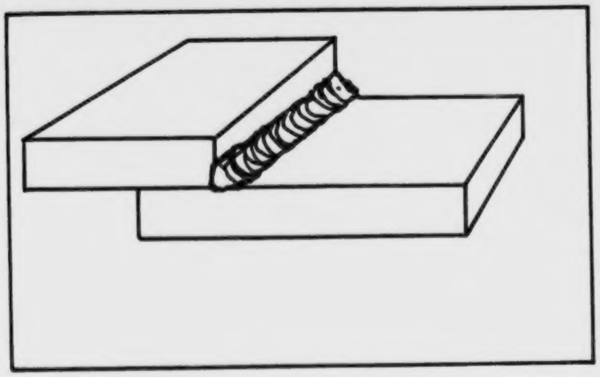
2. A **corner joint** is formed when pieces of metal are welded in the shape of an upside-down "V." The weld is placed where the two edges meet.



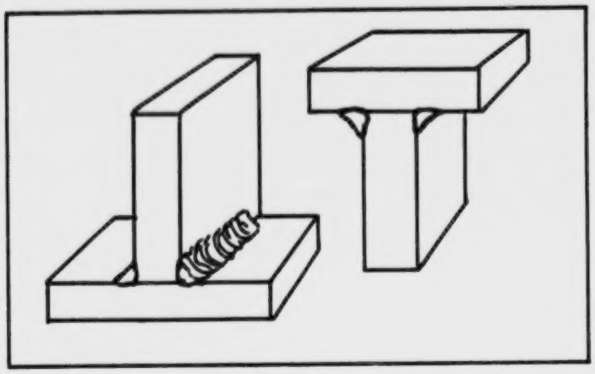
3. An **edge joint** is formed when the metal pieces are placed face to face. The weld is made on the edge of the pieces.



4. A lap joint is formed when pieces of metal are placed face to face so that they overlap. The edge of one piece is welded to the face of the other.

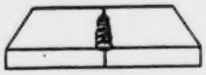


5. A tee ("T") joint is formed when pieces of metal are welded together at right angles to each other to form a "T" shape.

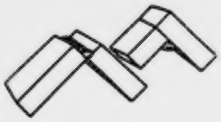


6. Remember: the five basic types of weld joints are:

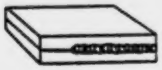
Butt joint



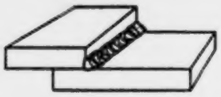
Corner joint



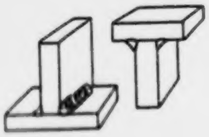
Edge joint



Lap joint

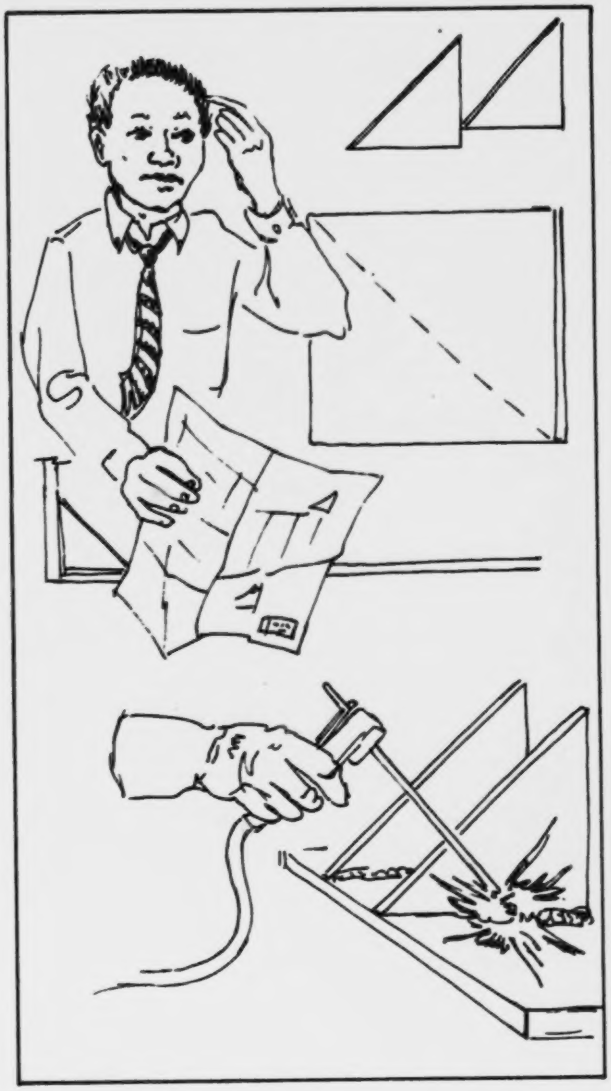


Tee joint



C. Selecting Weld Joints

To help prevent joint failures, the welder must think about how the joint will be used. The welder must know if the joint will be strong enough to do its job without failing. Often a weld fails because of poor planning or joint design.

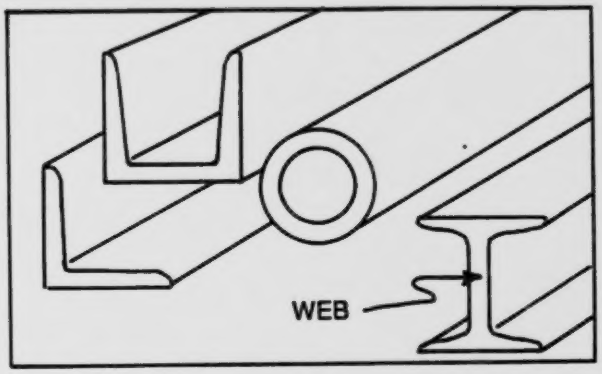


1. The welder or designer must consider several factors when choosing the proper joint to use. These factors are:
   - the amount and type of stress on the joint
   - the time required to make the weld
   - the cost of making the weld
   - the shape of the object being built
   - whether the joint can be welded from more than one direction.
2. After considering these factors, the welder or designer can choose the most economical weld joint that will carry the needed load.

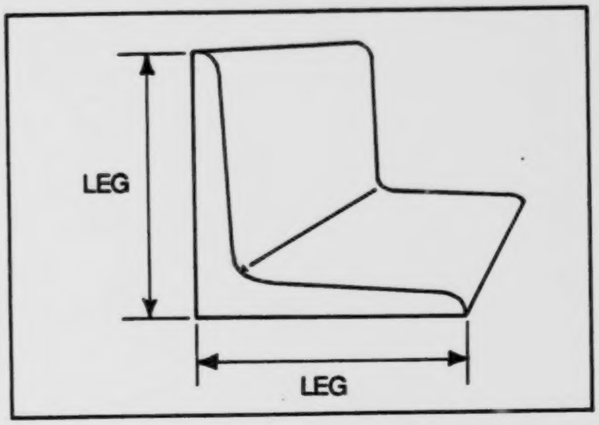
D. Identifying Structural Metal

The welder should be able to identify and name common structural metal shapes and know how each shape is sized.

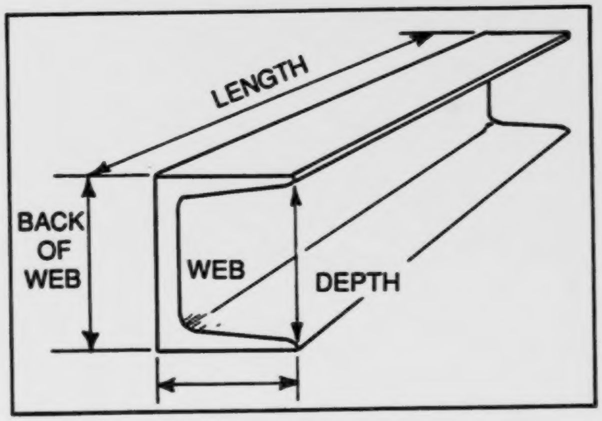
1. Structural metal is available in many different shapes. Designers and welders should select the best shape for the job being done.



2. **Angles** - when viewed from the side, an angle looks like an "L." The size of an angle is determined by the length and thickness of its legs. Angles commonly come in 20- and 40-foot lengths.

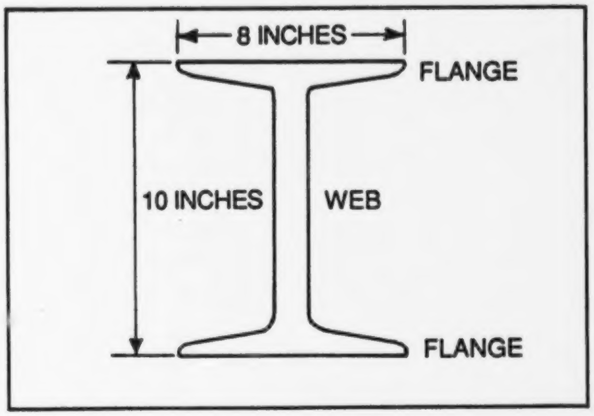


3. **Channels** - when viewed from the end, a channel looks like a block shaped "C." The size of a channel is determined by the depth, the weight per foot and the length. (For example: a 10" X 15.3 X 16' channel is 10" deep, weighs 15.3 lbs per foot and is 16' long.)



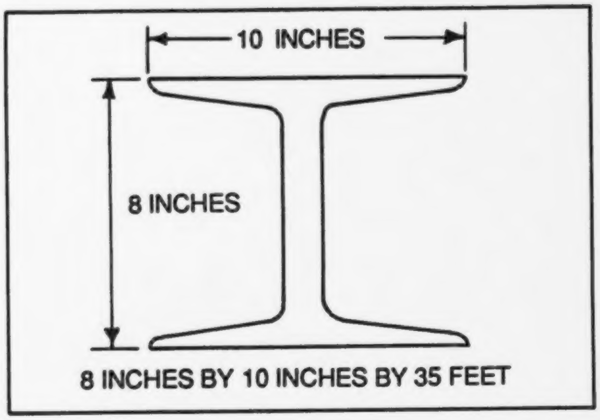
4. **Beams** - Two types of beams are commonly available.

   a. "S" beams (also called "I" Beams) have a web that is longer than the width of its flanges. The beam looks like the capital letter "I." The size of an "S" Beam is determined by the depth of its beam, the width of the flanges and the weight per foot of the beam's length.

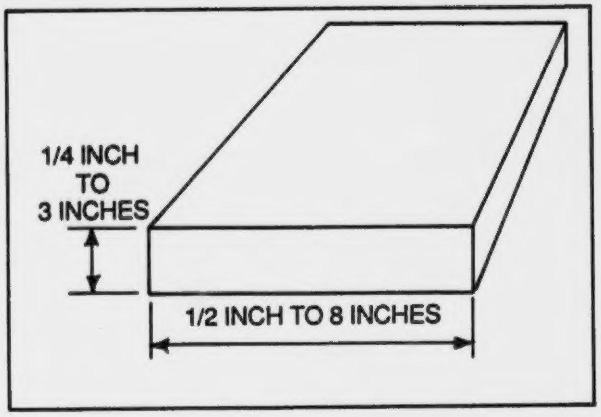

8 INCHES
FLANGE
10 INCHES
WEB
FLANGE

   - "Wide Flange" beams have flanges that are as wide or wider than the length of the web and are sized the same way "S" beams are:

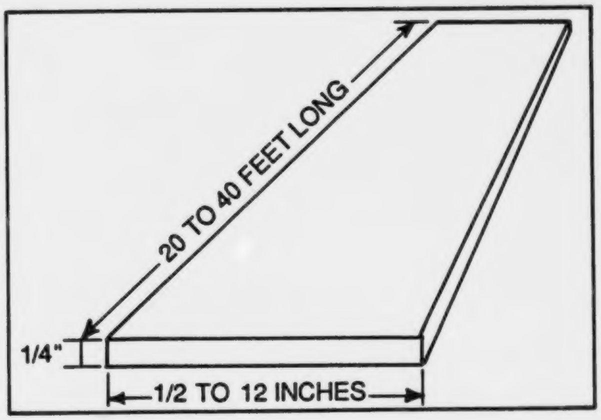
     (depth of the beam) X (width of the flanges) X (weight per foot of beam length).


10 INCHES
8 INCHES
8 INCHES BY 10 INCHES BY 35 FEET

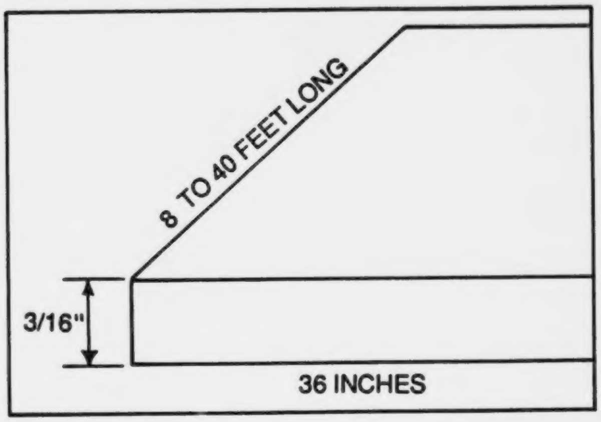
5. Flats, strips, plates and sheets are four types of metal that have no angles or curves.


1/4 INCH
TO
3 INCHES
1/2 INCH TO 8 INCHES

- **Flats** are pieces of metal from 1/4" to 3" thick and from 1/2" to 8" wide. Flats are commonly available in 20- and 40-foot lengths.


20 TO 40 FEET LONG
1/4"
1/2 TO 12 INCHES

- **Strips** are pieces of metal less than 1/4" thick and from 1/2" to 12" wide. Strips are commonly available in 20- and 40- foot lengths.

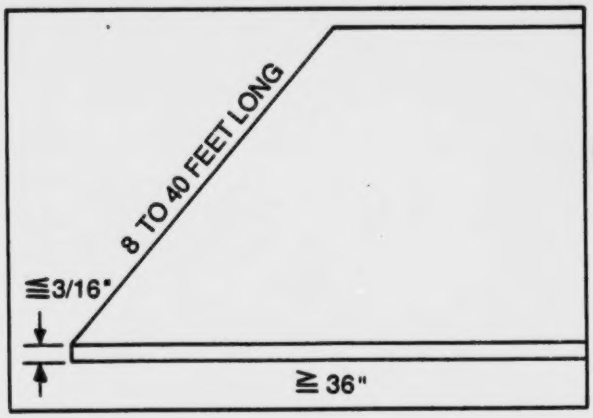

8 TO 40 FEET LONG
3/16"
36 INCHES

- **Plates** are pieces of metal more than 3/16" thick and from 36" to 86" wide. Plates commonly come in lengths of 8 to 40 feet.

(NOTE: Strips, plates and sheets are sized by their thickness, width and length.)

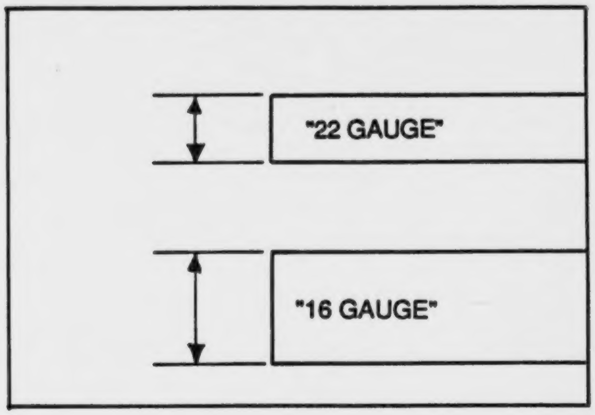
126

- **Sheets** are pieces of metal with a thickness of 3/16" or less and a width of 36" to 86". Sheets commonly come in lengths of 8 to 40 feet.

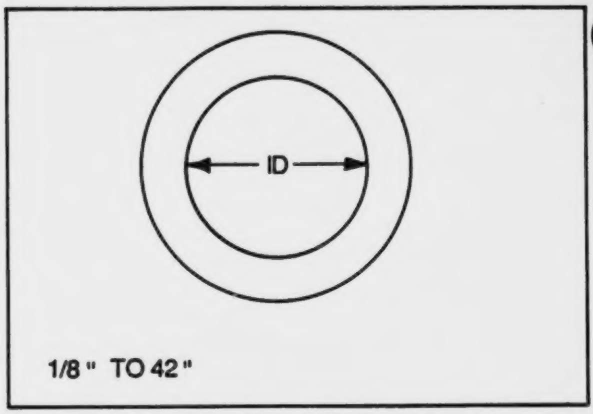


(NOTE: Sometimes the thickness of a sheet is measured in "gauge" numbers, such as "10 gauge," "16 gauge" or "20 gauge."

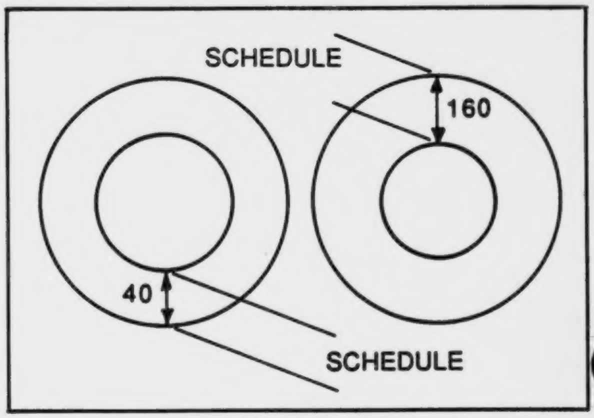
The rule to follow is: "the larger the gauge number, the thinner the sheet." For example, a 16 gauge sheet is thicker than a 22 gauge sheet.)



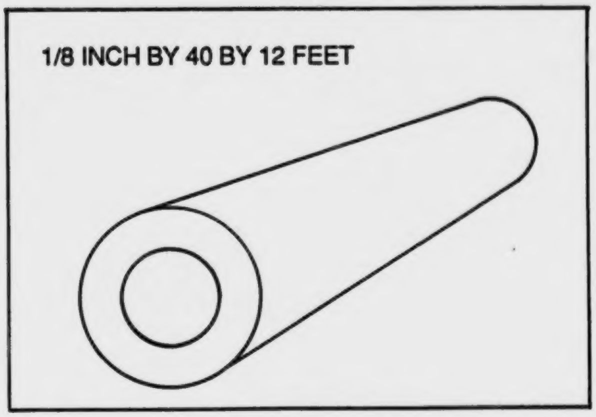
6. **Pipes** are round, hollow pieces of metal. The size of pipe is determined by measuring the inside diameter (ID), which can range from 1/8" to 42".



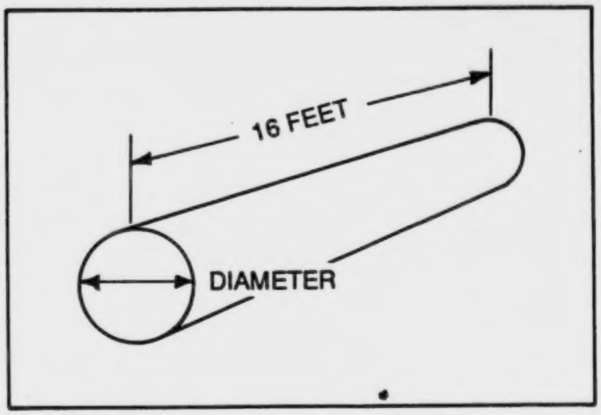
- Pipes are measured by the thickness of their walls. The wall thickness is known as "schedule." A higher schedule number means a thicker pipe wall. Schedule 40, 80 and 160 pipes are easy to get. Schedule 40 pipes are the most common.



- A pipe is sized by its inside diameter (ID), its wall thickness schedule and its length. Pipes are commonly available in standard 20- and 40- foot lengths.



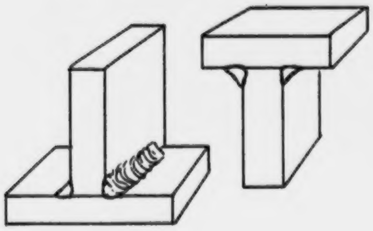
7. Rounds are solid circular pieces of metal, also known as rods or shafts. Rounds are sized by their diameter. They come in sizes from 1/32" to 6" in diameter and in standard lengths of 16, 18 and 20 feet.



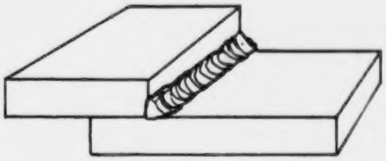
UNIT REVIEW

1. Identify the joints below:

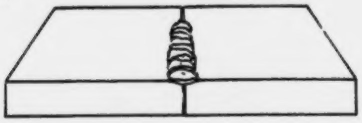
A.



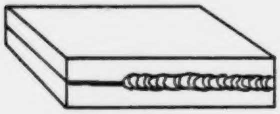
B.



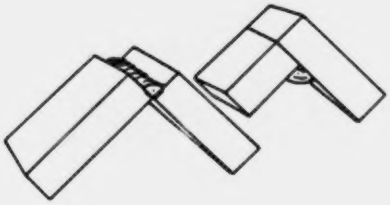
C.



D.



E.



2. What five factors should a welder or designer think about when deciding which type of joint to use for a particular weld?

____

____

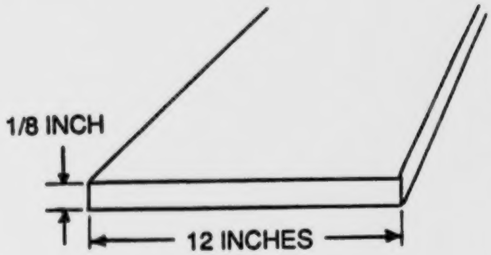
____

____

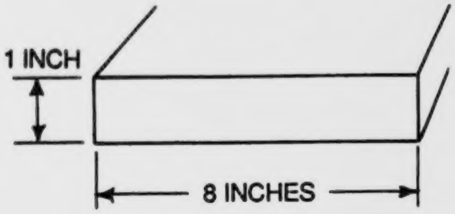
____

3. Identify the structural metal shapes shown below.

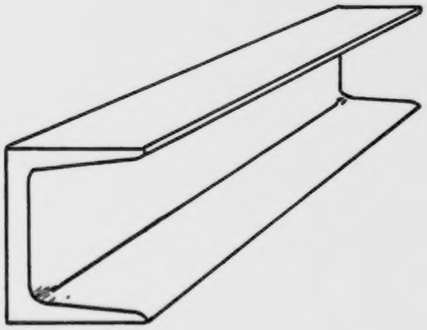
A. ______________________


1/8 INCH
12 INCHES

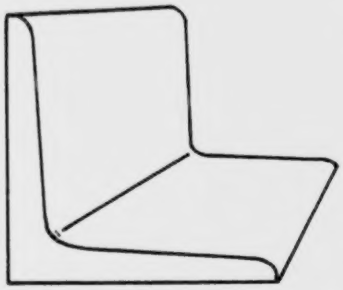
B. ______________________


1 INCH
8 INCHES

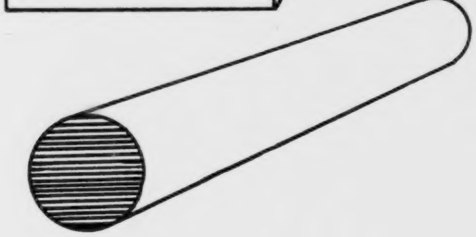
C. ______________________



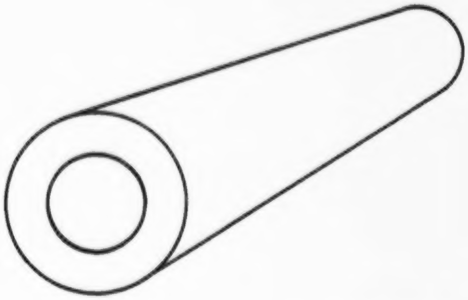
D. ______________________



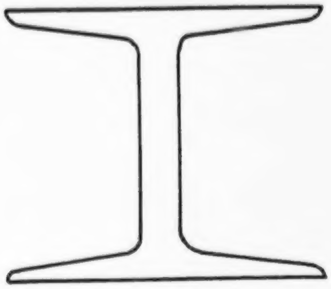
E. ______________________



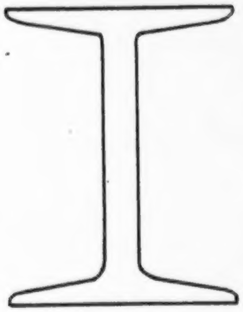
F. ______________________



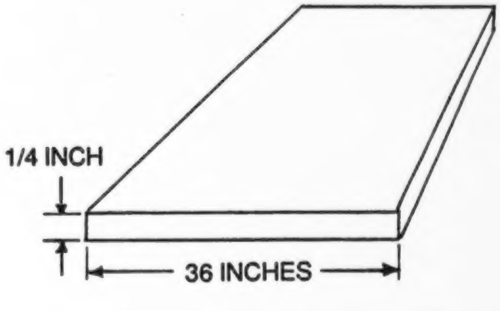
G. ______________________



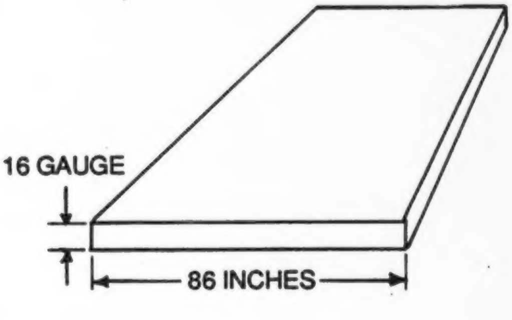
H. ______________________



I. ______________________

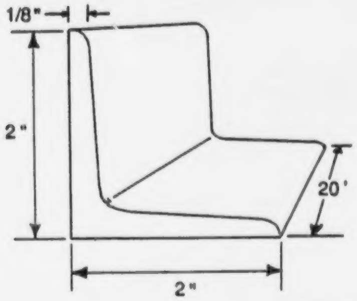

1/4 INCH
36 INCHES

J. ______________________

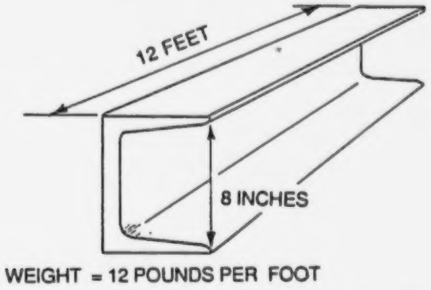

16 GAUGE
86 INCHES

4. Study the dimensioned drawings below. Write the correct size specifications for each structural shape. Make sure the specifications are in correct order.

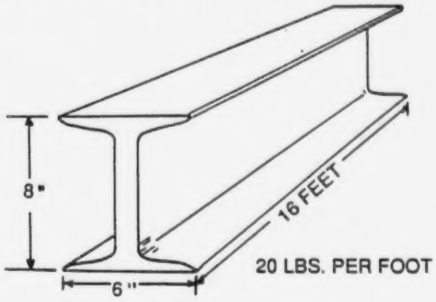
A.



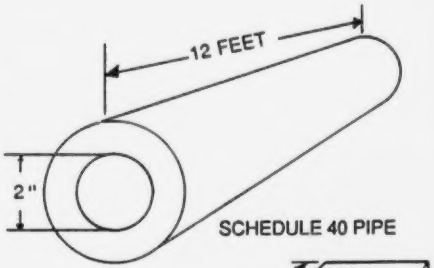
B.


12 FEET
8 INCHES
WEIGHT = 12 POUNDS PER FOOT

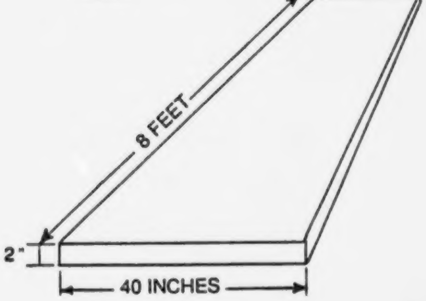
C.


8"
16 FEET
20 LBS. PER FOOT
6"

D.


12 FEET
2"
SCHEDULE 40 PIPE

E.


8 FEET
2"
40 INCHES

PERFORMANCE CHECKLIST

Student ______________________________ successfully performed the following tasks:

	Yes	No	Comments
1. Identified the five basic joint designs			
2. Listed the factors to consider when selecting a weld joint			
3. Identified basic metal structural shapes			
4. Wrote correct specifications for basic structural shapes			
5. Correctly specified sizes of structural steel			

Satisfactory - should move on ☐

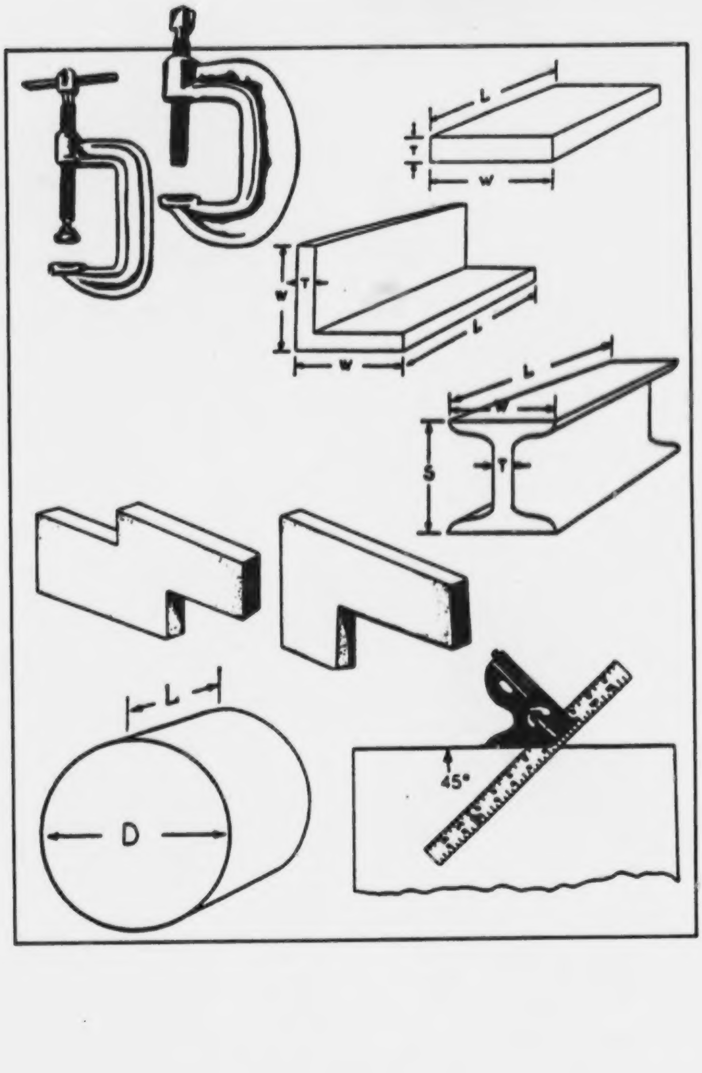
Should repeat this unit ☐

_________________________ Student's Signature/Date

_________________________ Instructor's Signature/Date

WELDING
Supplementary Units

Welding Terms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WELDING TERMS

INTRODUCTION

A welder must be able to understand many special welding terms and use them correctly so that he or she can communicate with other welders, supervisors and customers.

UNIT OBJECTIVES

After completing this lesson, you should be able to identify and define basic welding terms.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to specifically:

1. Describe steps for learning terms.
2. Identify and define welding terms.
3. Identify the four main weld positions.
4. Identify types of welds and their uses.
5. Identify types of beads and passes.
6. Identify common abbreviations used by welders.

ARE YOU READY?

CHECK THE STATEMENT THAT IS TRUE FOR YOU:

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

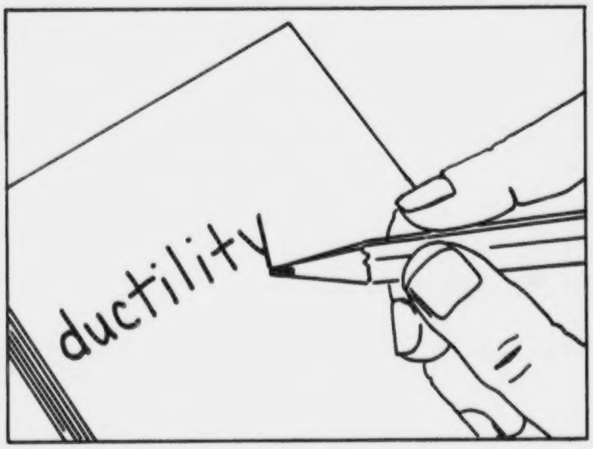
TURN PAGE AND BEGIN

A. Improving Understanding and Memory of Terms and Information

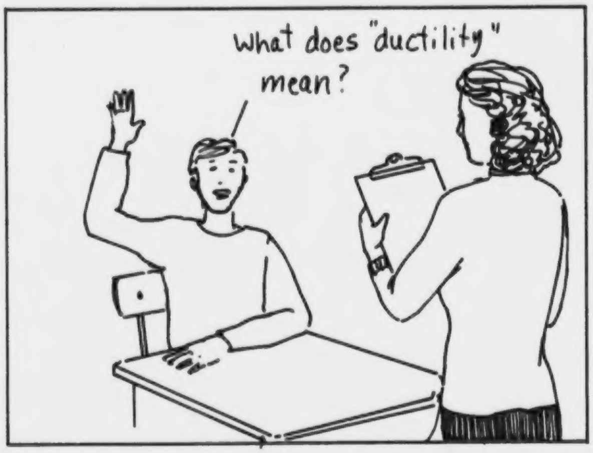
When learning new welding terms and reading information about welding, you can take steps to make new material easier to understand and remember. The steps below will help you learn the information in this unit.

Steps for Learning Terms

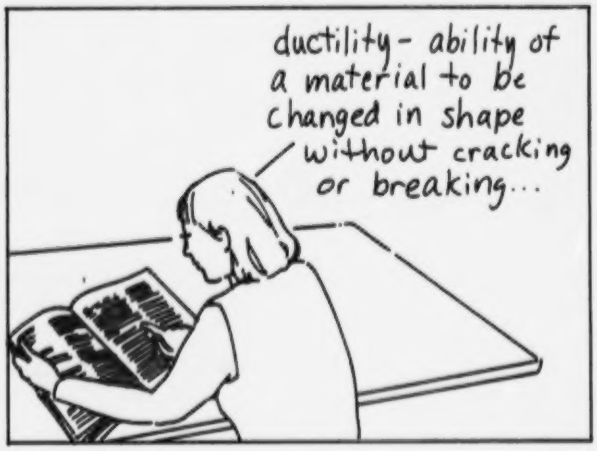
1. Write new words down. Keep 3" x 5" file cards or a small notebook in your pocket to help remember words and definitions.



- If you hear a word you don't know, ask what it means.

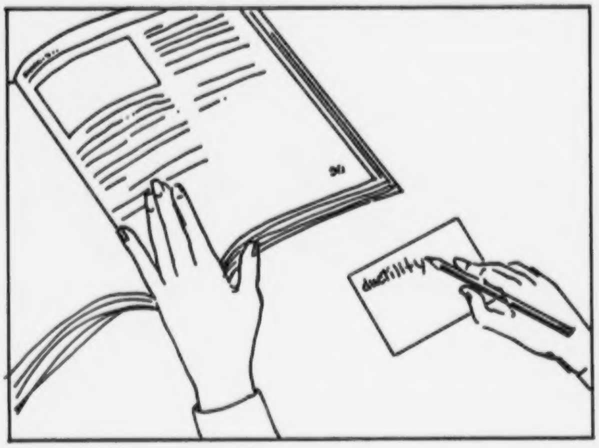

What does "ductility" mean?

- If you are unable to ask, look the word up later in a dictionary or the glossary at the back of your book.

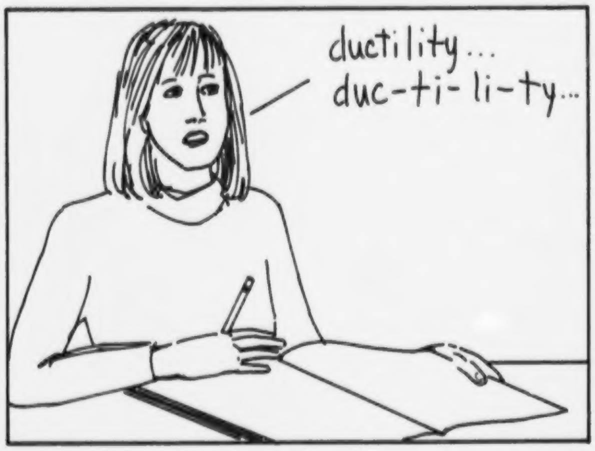

ductility - ability of a material to be changed in shape without cracking or breaking...

- If the word is printed in your textbook, write it down anyway to help you remember it.

- Use your cards or notebook to look up words you've forgotten and to help you study.

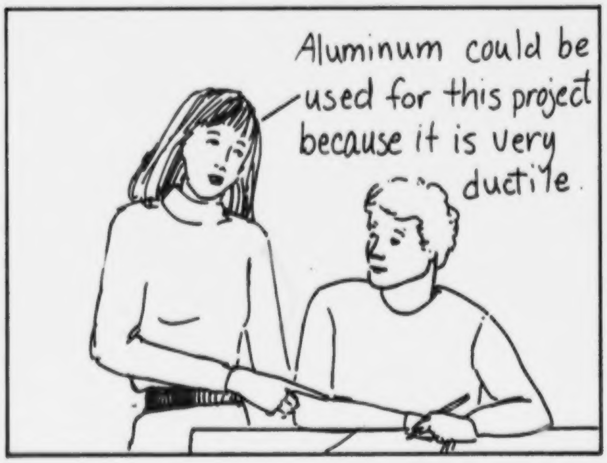


2. Say the word out loud several times to help you remember new words.

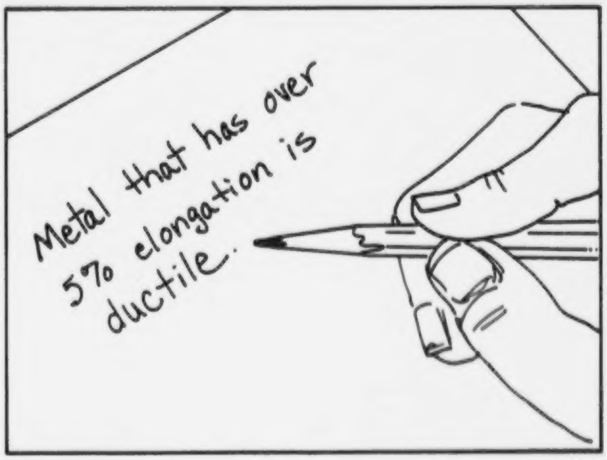

ductility...
duc-ti-li-ty...

3. Use the word:

   - When you talk to your instructor or to other students.


Aluminum could be used for this project because it is very ductile.

   - When you take notes.


Metal that has over 5% elongation is ductile.

   - When you are in class and thinking about what you are doing.

Steps for Reading Material

1. Look at the TITLE of the reading selection and think of questions you have about the subject. Plan to answer those questions when you finish reading.

2. Look over the paragraphs to be read for words in LARGE OR DARK PRINT. These words are large or dark on purpose. They show which information is most important and give clues about what you need to review later.

Types of Light Produced by the Welding Arc

The electricity produced by a welding machine can be dangerous. The welding arc exposes welders to **three types of light: ultraviolet, infrared and visible. Visible** light is the light you can see. It is not harmful to the welder. However, because both ultraviolet and infrared light are harmful, the welder must take appropriate safety precautions to prevent exposure.

Ultraviolet light (light that has a shorter wavelength than visible light) cannot be seen or felt. It is dangerous because the welder may not be aware of his or her exposure to it. Ultraviolet light can cause severe eye and skin burns after only seconds of exposure.

Like ultraviolet light, **infrared** light (light that has a longer wavelength than visible light) can also not be seen; however, it can be felt as heat, allowing the welder to detect exposure and take proper corrective action. Infrared light can cause mild to severe burns of the epidermis. These burns on the skin can be more painful than sunburns.

Welders can protect themselves from the harmful effects of exposure to ultraviolet and infrared light by following three safety precautions. **First**, always **wear** an approved, well-maintained **welding helmet** equipped with the proper shade of filter lens. **Second**, always **wear** approved **leather gloves** to protect the hands. **Third**, always **wear non-flammable clothing** that covers the entire body. By following these three precautions, a welder can avoid harmful exposure to ultraviolet and infrared light.

NOTE: Sometimes special print, like italics, or underlining is used to mark important words and ideas.

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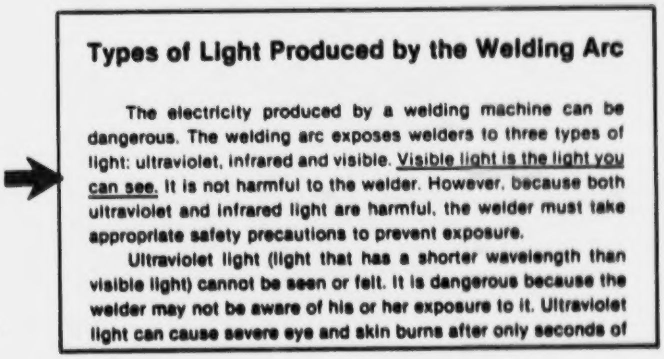
3. Start at the beginning and read the selection. If you see **TERMS** you do not know, find out what they mean. Here's how:

a. Sometimes the writer tells you what the word means.



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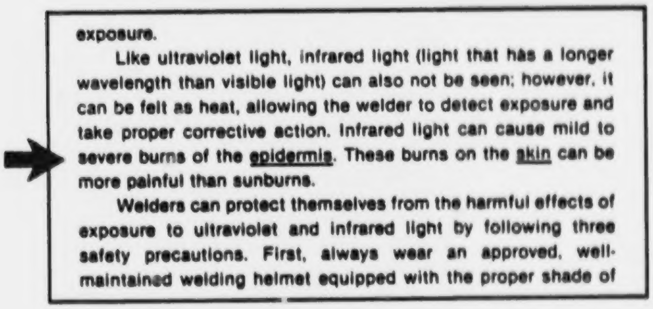
b. Sometimes the writer explains a new word by using another word that means almost the same thing.



exposure.

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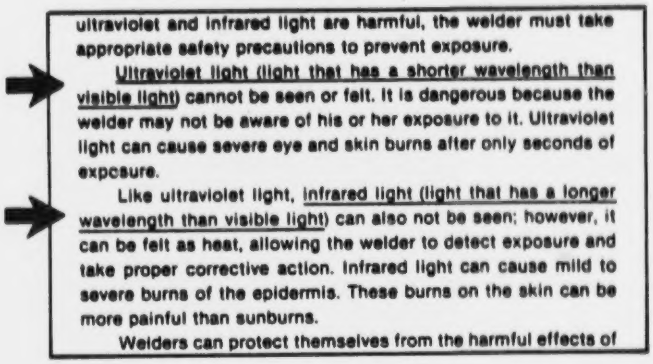
Welders can protect themselves from the harmful effects of exposure to ultraviolet and infrared light by following three safety precautions. First, always wear an approved, well-maintained welding helmet equipped with the proper shade of

c. Sometimes the writer uses a new word and tells what it means in parentheses afterwards.



ultraviolet and infrared light are harmful, the welder must take appropriate safety precautions to prevent exposure.

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Welders can protect themselves from the harmful effects of

d. Sometimes you can figure out what the word means by the way it is used in the text.

Types of Light Produced by the Welding Arc

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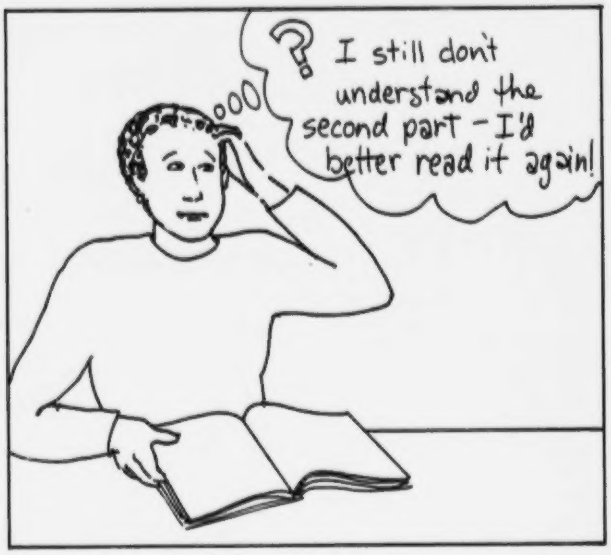
e. Sometimes you have to look the word up in your notes, a dictionary or the glossary at the end of your textbook.

vis•i•ble (viz'ə b'l) adj. 1. that can be seen; perceptible by the eye 2. that can be perceived or observed; apparent; evident; manifest [no visible improvement] 3. on hand or available [visible supply] 4. so constructed as to bring to view parts or elements that are normally not perceptible -- vis'i•bly adv.

from Webster's New World Dictionary, Second College Edition, 1984.

4. A writer puts information into a text for a reason. As you finish each paragraph, stop and ask yourself "what's the point of this?," "what can I learn from this?" and "why did the writer give this information?"

   If you can't answer these questions after reading the material, read the information again and figure out the answers.


I still don't understand the second part - I'd better read it again!

5. **Take notes or make an outline that shows the most important ideas and information you read.**

   - When you take notes, write down new information in your own words. Using your own words makes new information easier to remember and study later.

discontinuities - flaws (gaps or cracks) in a weld. These are defects if the weld can't be used to do the job.

weld inspection - find discontinuities and how big they are.

NDT - Test the weld without hurting the weld in order to find out how good the weld is.

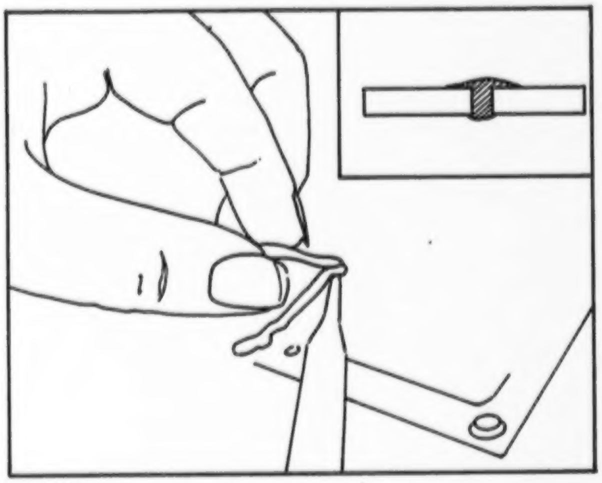
   - When you make an outline, organize new information so more important ideas are distinct from less important ones.

     You can use the outline later to help do assignments and review for tests.

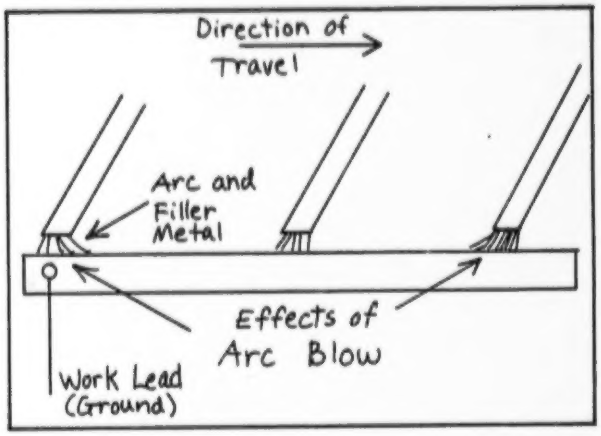
II. Weld inspection
    A. Find flaws
    B. Find size of flaws
    C. Check weld without hurting weld (N.D.T.)
III. Destructive testing
    A. Find what effect flaw has
    B. Find out how long a weld can last.
    C. This Kind of testing destroys the weld.

B. Basic Welding Terms

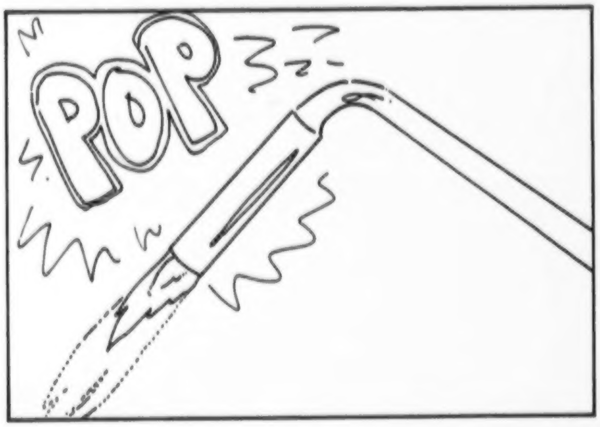
1. **Adhesion** - a process that joins metals together without melting them. Brazing and soldering are welding methods that join metals by adhesion.



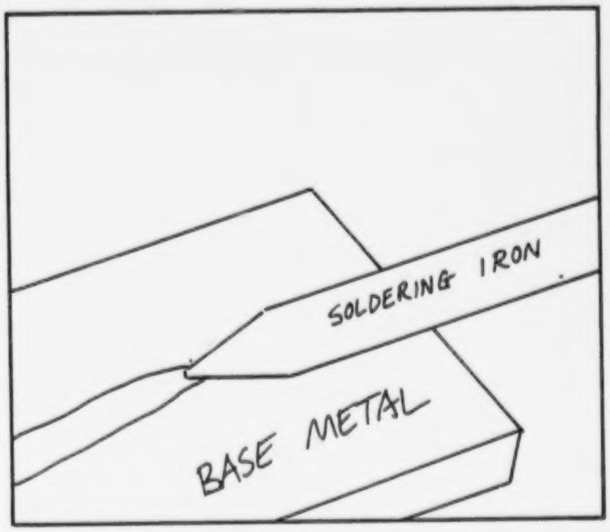
2. **Arc blow** - the wavering of an arc from its normal path because of magnetic disturbance.


Direction of Travel
Arc and Filler Metal
Effects of Arc Blow
Work Lead (Ground)

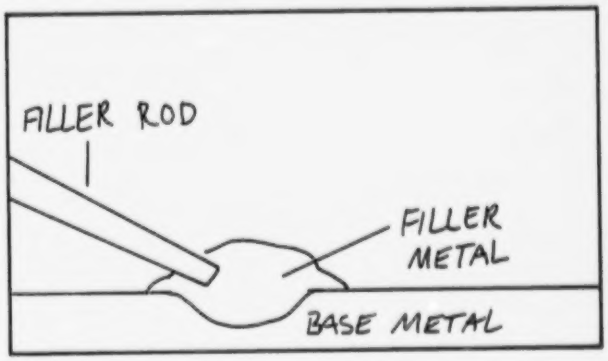
3. **Backfire** - a condition that occurs when the oxyacetylene flame goes out with a loud "pop."



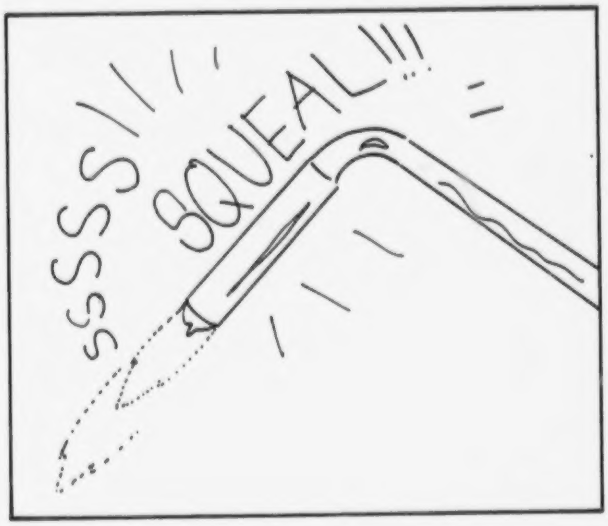
4. **Base metal** - the metal to be welded or cut; it is also called the "parent metal."


SOLDERING IRON
BASE METAL

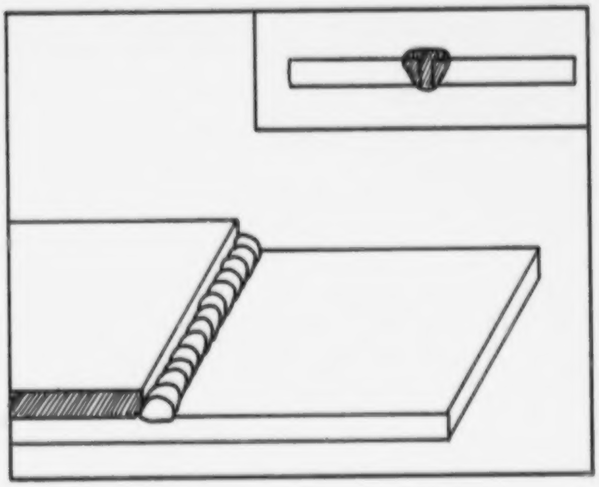
5. **Filler metal** - the metal added when making welded, brazed or soldered joints.


FILLER ROD
FILLER METAL
BASE METAL

6. **Flashback** - the condition that occurs when the oxyacetylene flame burns back into the welding tip or torch. A shrill hissing or squealing sound is produced. **A FLASHBACK MAY MEAN A SERIOUS EQUIPMENT PROBLEM.**

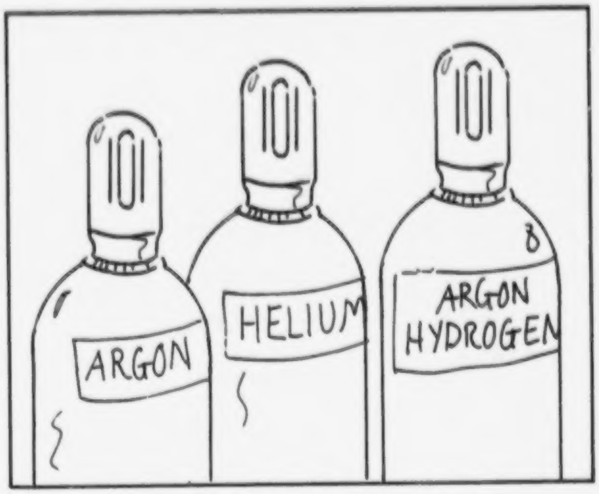

SSSSS
SQUEAL!!!

7. **Fusion** - a process that joins metals by melting them together. It can be accomplished with or without a filler rod.

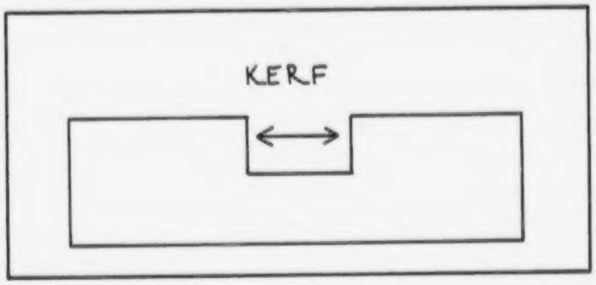


8. **Inert gas** - a gas that normally does not chemically combine with the base or filler metals.

   Argon, helium and argon-hydrogen are examples of inert gases.



9. **Kerf** - the space made when a metal has been cut.



DO SKILL SHEET 1.

SKILL SHEET 1

BASIC TERMS

Directions: Fill in each blank below with the welding term that fits the statement.

adhesion
base metal
inert gases
arc blow
filler metal
kerf
backfire
fusion
flashback

1. ____________________ is when the arc wavers from its normal path because of magnetic disturbance.

2. ____________________ is the metal to be welded.

3. ____________________ is the space made when metal has been cut.

4. ____________________ is a way of joining metals together without melting them.

5. ____________________ means melting metals together to join them.

6. ____________________ such as argon, helium or argon-hydrogen, do not normally combine chemically with the molten base metal.

7. ____________________ causes a loud "pop" when the oxyacetylene flame goes out.

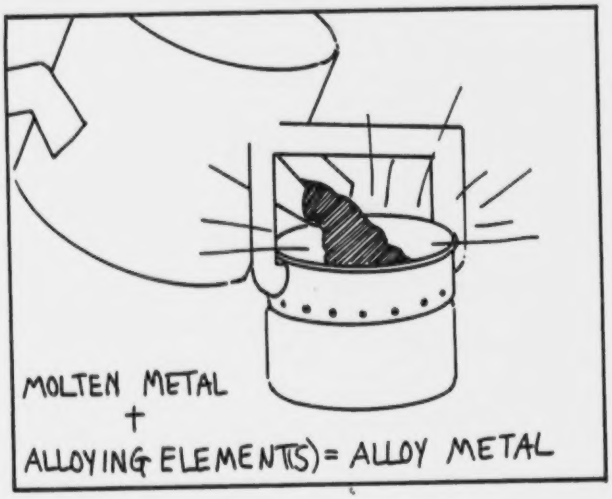
8. ____________________ is the metal added when making fusion, brazed or soldered welds.

9. ____________________ is when the oxyacetylene flame burns back into the welding tip or torch.

C. Terms That Describe Characteristics of Metals

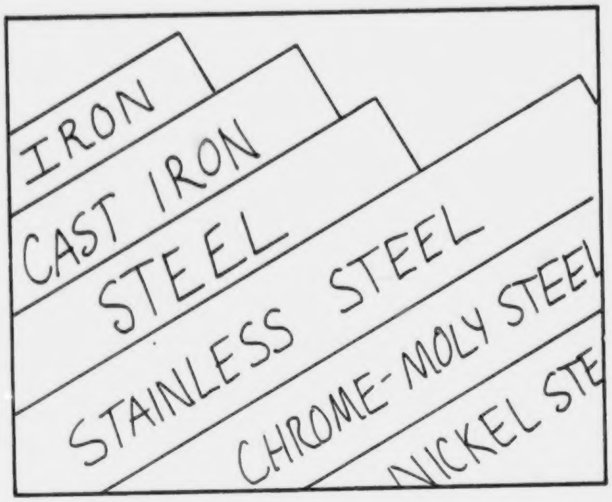
1. **Alloy** - a metal made by combining a pure metal and another metal or element while they are melted.

   Steel is an alloy. It is a mixture of iron and small amounts of carbon.


MOLTEN METAL
+
ALLOYING ELEMENT(S) = ALLOY METAL

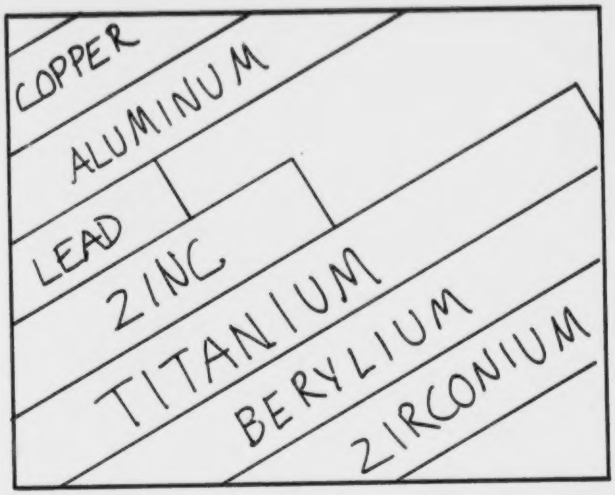
2. **Ferrous metals** - the metals that have iron as their main ingredient. Most ferrous metals are magnetic.

   Iron and steel are ferrous metals.

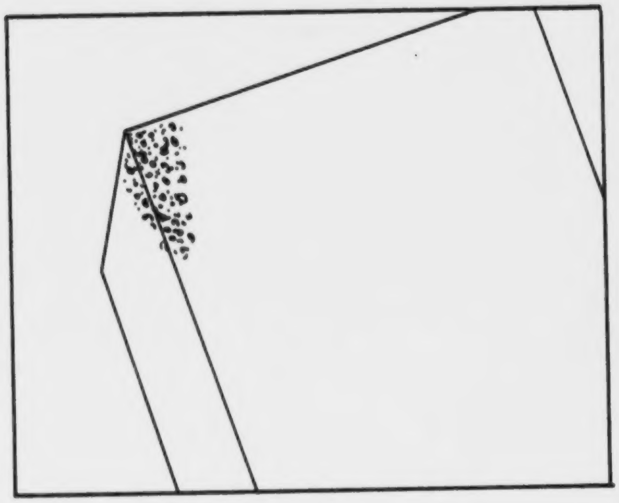

IRON
CAST IRON
STEEL
STAINLESS STEEL
CHROME-MOLY STEEL
NICKEL STE

3. **Nonferrous metals** - the metals that do not contain iron. Nonferrous metals are not magnetic.

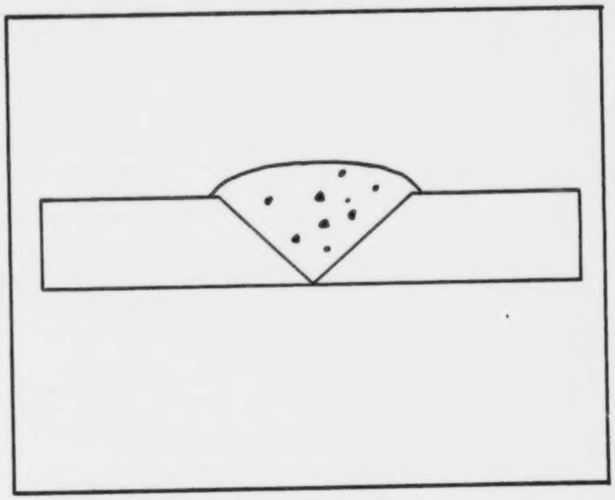
   Aluminum and copper are nonferrous metals.


COPPER
ALUMINUM
LEAD
ZINC
TITANIUM
BERYLIUM
ZIRCONIUM

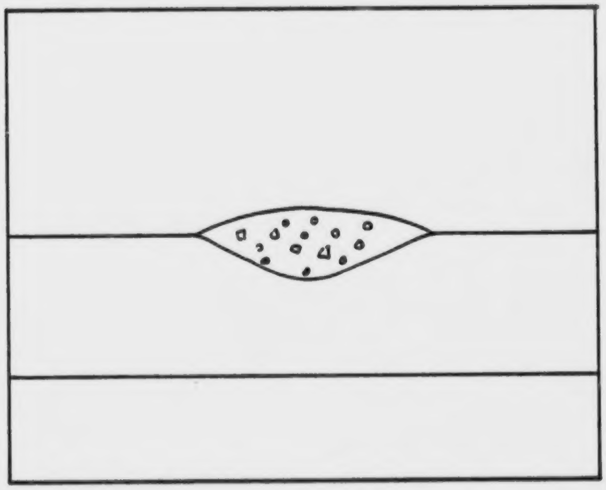
4. **Oxide** - the scale that forms on metal surfaces when they are exposed to air. Oxides form faster when metal is heated.



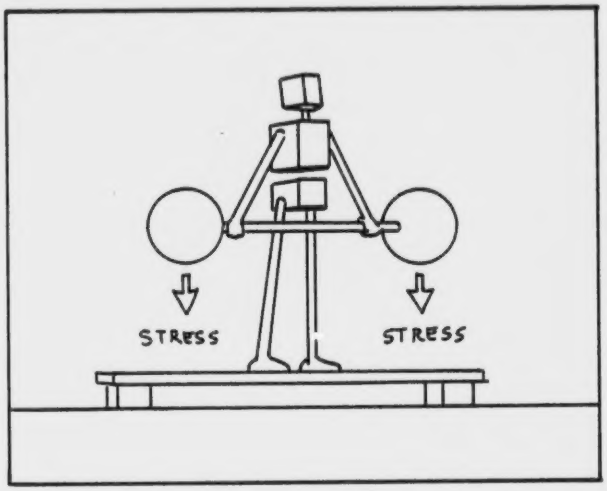
5. **Inclusion** - the small particles, which do not belong in metal, that get into welds and casted metals and weaken the metal.



6. **Porosity** - the presence of gas pockets or empty spaces (voids) in metal or weld that weaken the metal.

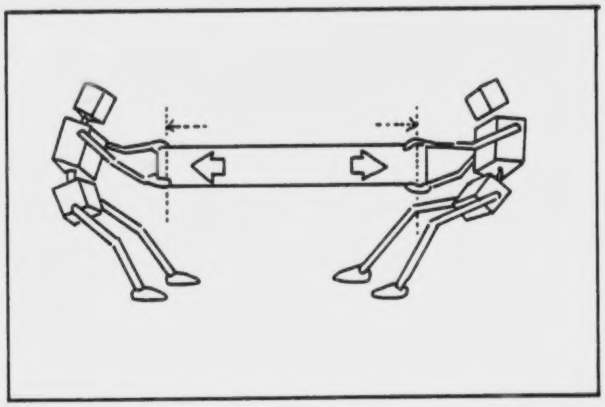


7. **Stress** - the load or amount of force put on an object. Stress tends to deform or break an object.



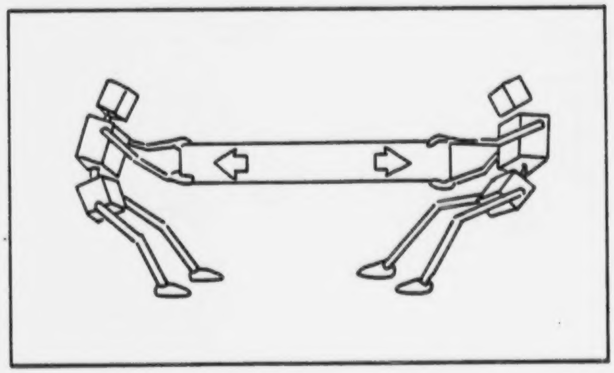
8. **Elongation** - the amount of stretching a metal will take before it breaks.

NOTE: Percent of elongation is measured in a tensile test.



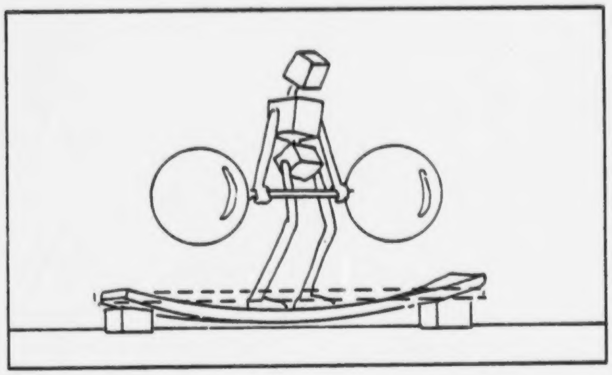
9. **Tensile strength** - the ability of an object to resist a force trying to pull the object apart.

   NOTE: Tensile strength is measured in pounds per square inch (psi).



10. **Yield strength** - the amount of stress at which a metal becomes permanently deformed.

    NOTE: Yield strength is measured in psi.



DO SKILL SHEET 2.

SKILL SHEET 2

TERMS THAT DESCRIBE CHARACTERISTICS OF METAL

Directions: Circle the correct terms to finish each sentence below.

1. Welds and casted metals can contain _(alloys, inclusions)__, which are small particles.

2. When metal is exposed to air, _(oxides, ferrous metals)_ form on the metal surface.

3. Gas pockets, small particles or empty spaces in a weld are signs of ______(porosity, oxides)_.

4. Copper, Aluminum, lead and zinc are all _(ferrous, nonferrous)_ metals.

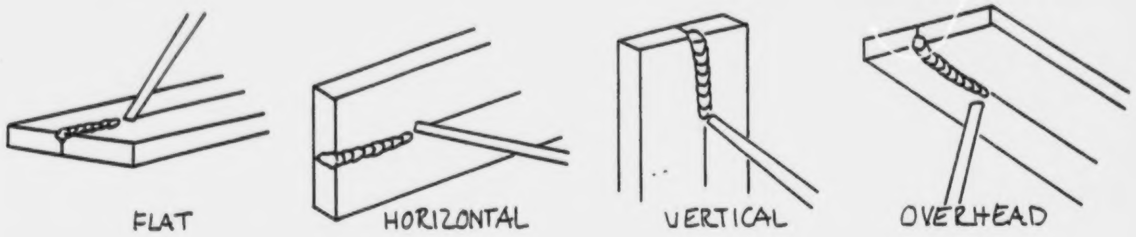
5. Iron and steel are _(ferrous, nonferrous)_ metals.

6. (Elongation, Stress) is another word for stretching.

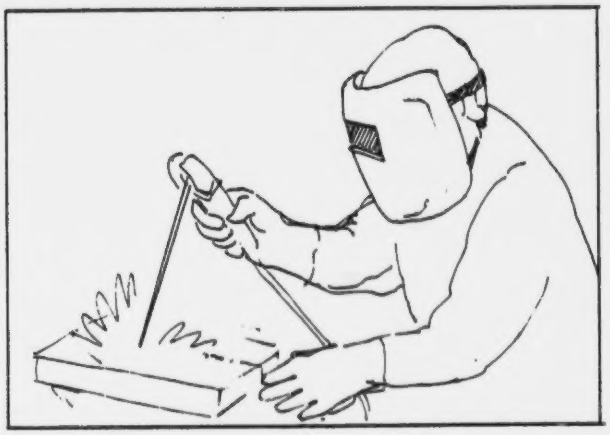
7. How much pulling a metal can withstand depends on the metal's __(yield strength, tensile strength)_.

D. Terms That Describe Welding Positions

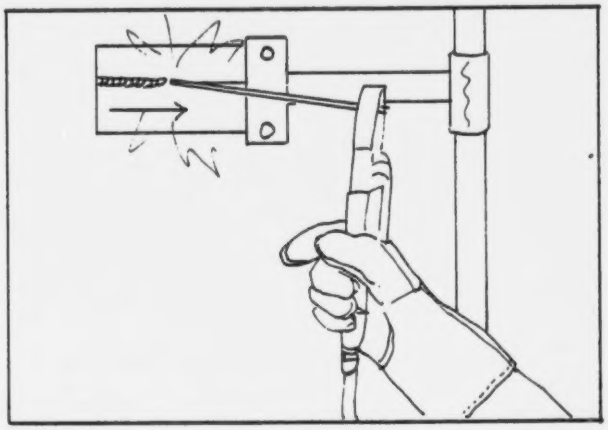
There are four main welding positions: flat, horizontal, vertical and overhead. Welds should be made in the flat position, if possible. Sometimes special turntables may be used to turn the work so the weld can be made in the flat position. Because of the size or location of some projects, however, many welds must be made in vertical, horizontal or overhead positions.



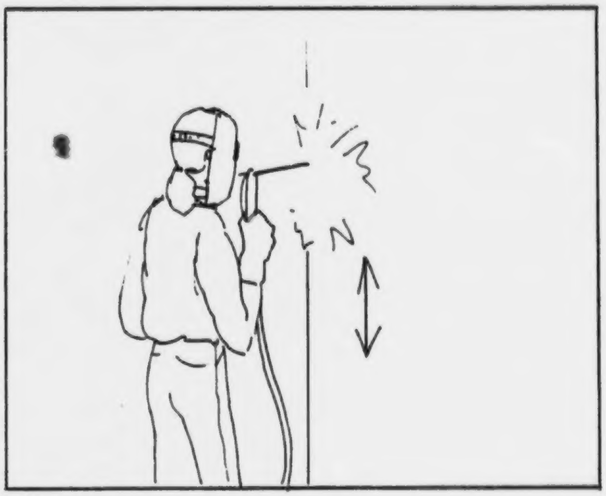
1. **Flat** - also called the "down-hand" position. The face of the weld is almost horizontal. The weld is made on the top side of the joint.



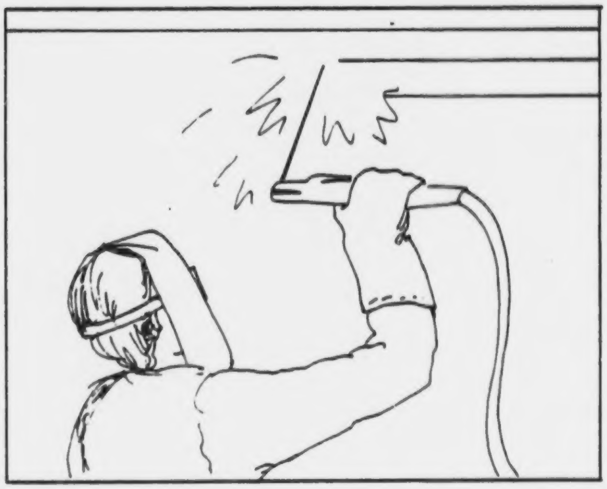
2. **Horizontal** - the weld is made on a horizontal (side to side) seam with the metal in an almost vertical (up and down) position.



3. **Vertical** - the weld is made on a vertical (up and down) seam with the metal in an almost vertical position.



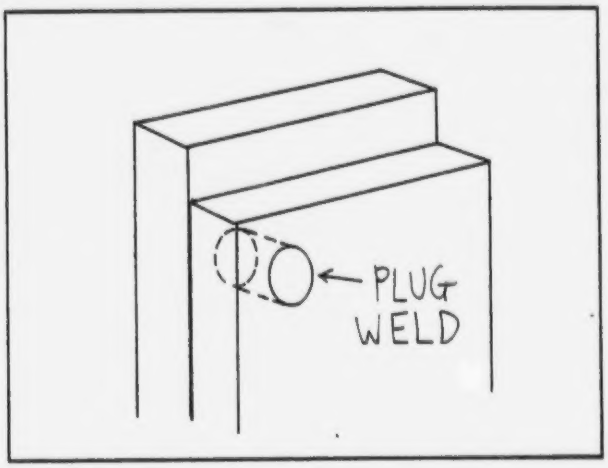
4. **Overhead** - the seam of the weld is almost horizontal. The weld is made on the underside of the joint.

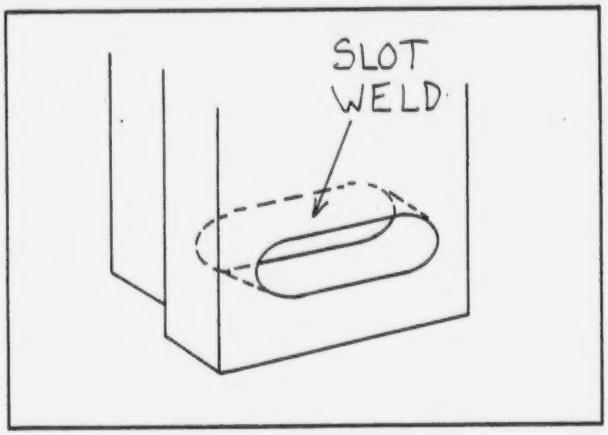


E. Terms That Describe Special Types of Welds

1. Plug welds and slot welds are used to weld two pieces of metal together at places away from the edges.

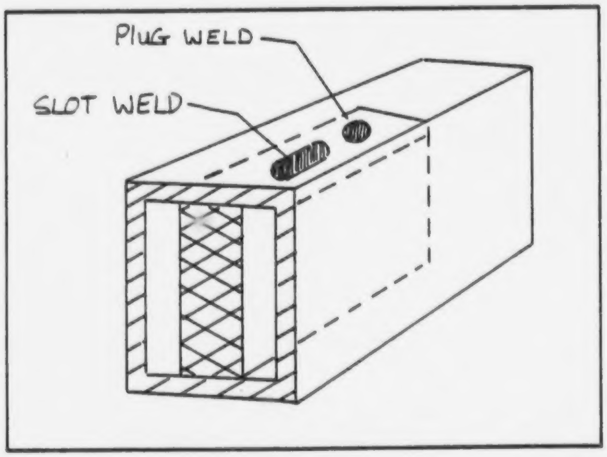
   - **Plug weld** - a weld made through a round hole in one member of a lap or tee joint.



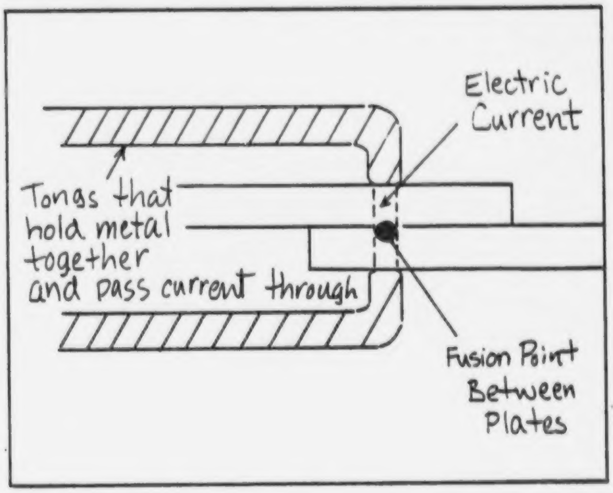


   - **Slot weld** - a weld made through an elongated hole in one member of a lap or tee joint.

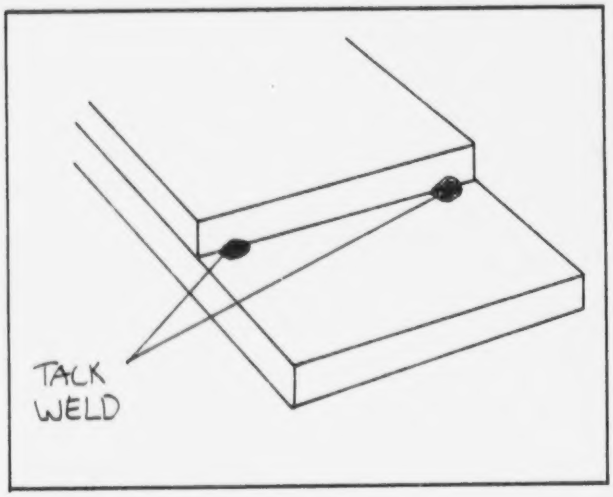
   NOTE: Slot welds and plug welds are often used when one member must fit completely inside another member.



2. **Spot weld** - a weld made when two pieces of metal are pressed tightly together between two electrodes. An electric current passes through the electrodes and causes the area between them to fuse together.


Electric Current
Tongs that hold metal together and pass current through
Fusion Point Between Plates

3. **Tack weld** - a small, temporary weld often used to hold parts in place until a permanent weld can be made.



DO SKILL SHEET 3.

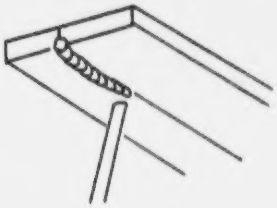
SKILL SHEET 3

TERMS THAT DESCRIBE WELDING POSITIONS AND SPECIAL TYPES OF WELDS

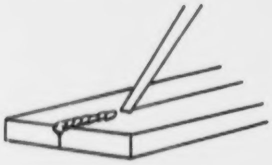
Directions: Use the new terms you have learned to identify the pictures below.

flat horizontal vertical overhead
plug weld slot weld spot weld tack weld

1. Here are the four main welding positions. In the space beneath each picture, write the name of the position shown.



a. ____________



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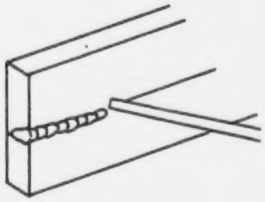
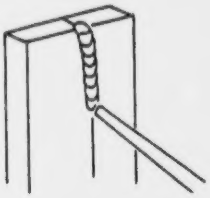
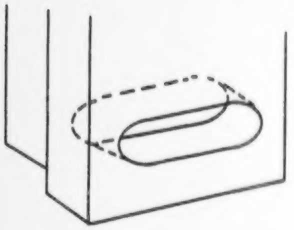


c. ____________

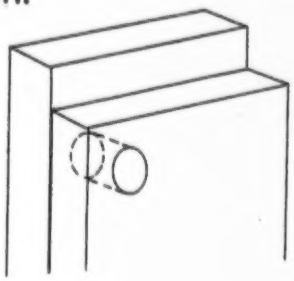


d. ____________

2. Here are some special types of welds. In the space beneath each picture, write the name of the weld shown.



a. __________



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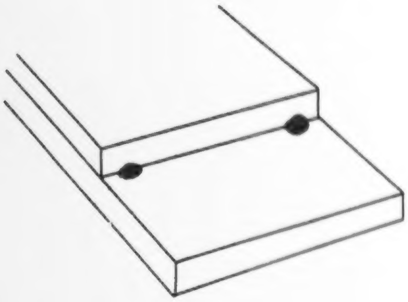

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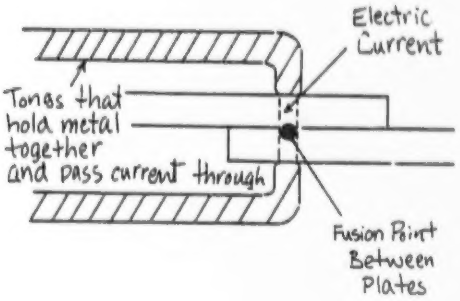
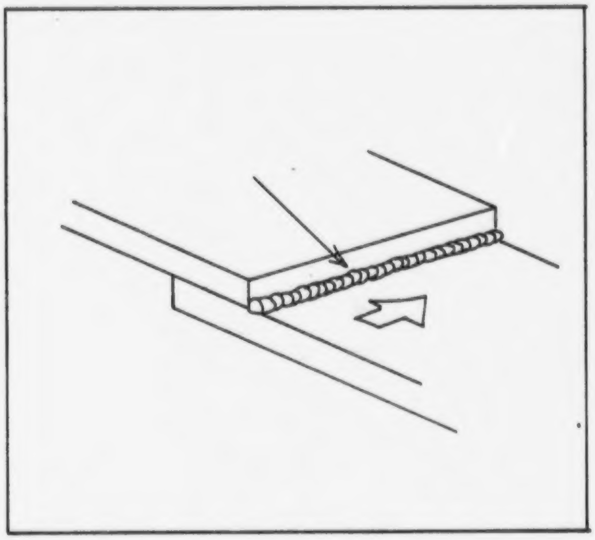

Electric Current
Tongs that hold metal together and pass current through
Fusion Point Between Plates

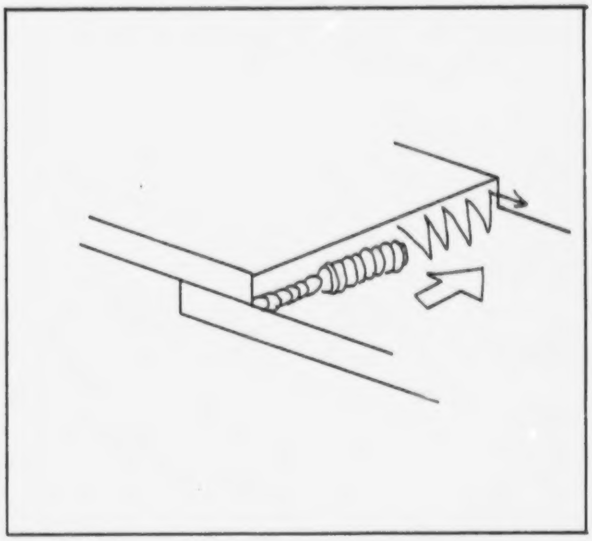
d. __________

F. Terms That Describe Types of Beads and Passes

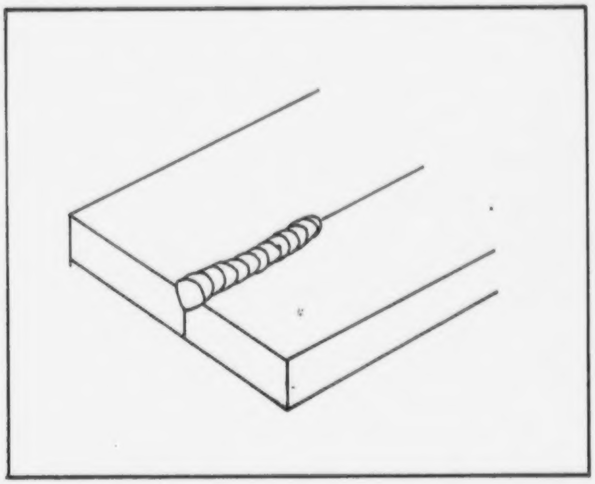
1. **Stringer bead** - a bead made with a straight pass of the electrode. This makes a narrow bead.



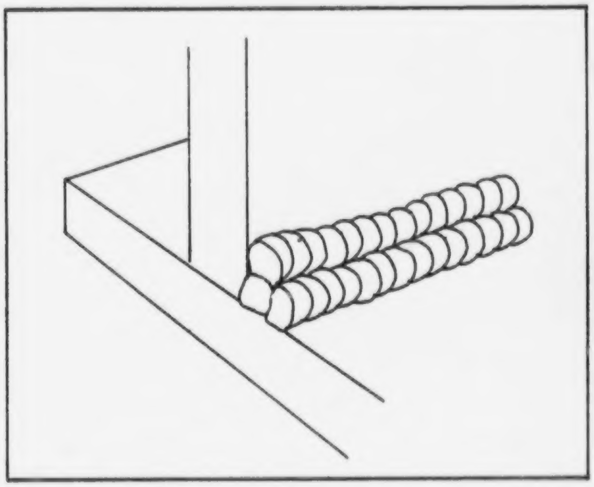
2. **Weaving bead** - a bead made with the electrode moved evenly back and forth across the weld joint. The bead is wider than a stringer bead. This bead is usually used as a cover pass in multiple-pass welds.



3. **Single pass** - a weld made in only one pass.



4. **Multiple pass** - a weld made in two or more passes.



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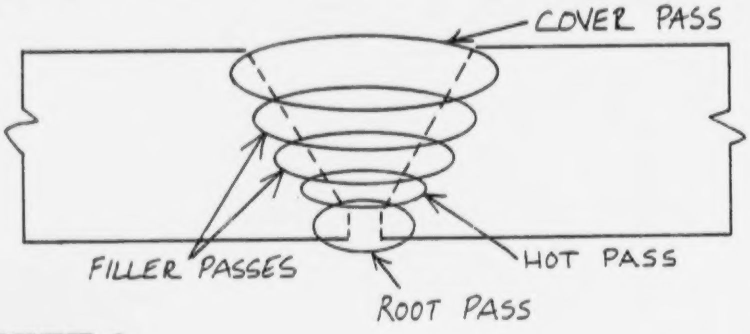
5. **Root pass** - the first pass in a multiple-pass weld. When the root pass is completed, the slag must be removed. Sometimes, the root pass is partially ground out to remove any high spots or "crowns."

6. **Hot pass** - the second pass in a multiple-pass weld. The hot pass uses more current than the root pass. It must fuse well with the root pass and the base metal and melt any slag left from the root pass. The hot pass is usually welded within five minutes after the root pass.

7. **Filler passes** - passes used to fill the weld joint. Several filler passes may be needed. Filler pass welds may be stringer beads or a slight weave may be used. Each filler pass must fuse (melt) into both the previous pass and the base metal.

8. **Cover pass** - the last pass of a multiple pass weld. The cover pass is used to cover the weld joint. A weaving motion is used to make a wide bead. There must be good fusion into all the previous weld passes and the base metal.



DO ACTIVITY SHEET 1.

ACTIVITY SHEET 1

WORKING WITH WORDS

Directions: Your instructor will give you a reading assignment in your textbook or in material he provides. After you read the assignment:

1. Check off the steps below that you followed.

_________ Looked for words in large or dark print.

_________ Wrote down new words.

_________ Found the meaning of new words.

_________ Asked "what's the point of this?," "what can I learn from this?" and "why did the writer give this information?"

_________ Read hard-to-understand material over again.

_________ Took notes.

2. List two new words you found and tell what they mean.

a. ____

____

____

b. ______________________________

____

____

3. Make notes that tell the main points you learned from the reading.

G. Common Welding Abbreviations

An abbreviation is a short way to write a word or name. Sometimes it is easier to use an abbreviation than to write out the longer word, especially if the word is used often. Abbreviations are helpful in references and blueprints because they take up less space. The list below contains common welding terms and their abbreviations.

Alternating current	A.C.
American Welding Society	A.W.S.
American wire gauge	A.W.G.
Angle	∠
British thermal unit	B.T.U.
Center line	℄
Cold rolled steel	C.R.S.
Cubic feet per minute	C.F.M.
Diameter	Dia.
Detail	Det.
Direct current	D.C.
Figure	Fig.

Gauge	Ga.
Hot Rolled Steel	H.R.S.
Inside diameter	I.D.
Outside diameter	O.D.
Radius	rad. or r
Revolutions per minute	r.p.m.

DO SKILL SHEET 4.

SKILL SHEET 4

WELDING ABBREVIATIONS

Directions: This chart shows abbreviations commonly used in welding. Some of the words and abbreviations are missing. Complete the chart by writing the correct word or abbreviation in each empty space.

1.		A.C.
2.	American Welding Society	
3.		A.W.G.
4.		∠
5.	British thermal unit	
6.		℄
7.	Cold rolled steel	
8.	Cubic feet per minute	
9.		Dia.
10.	Detail	
11.		D.C.
12.		Fig.

13. Ga.

14. H.R.S.

15. Inside diameter

16. Outside diameter

17. Radius

18. r.p.m.

WELDING TERMS

UNIT REVIEW

1. Match each term below with its correct definition.

arc blow fusion kerf

stress adhesion

a. __________ joining metals by melting them together

b. __________ joining metals together without melting them

c. __________ the wavering of an arc from its normal path because of magnetic disturbance

d. __________ the space made when metal has been cut

e. __________ the load or amount of force put on an object

2. Write the word in the blank that best completes each statement.

a. ________ is a material made up of a metal and another element.

b. ________ strength is the stress point at which metal becomes permanently deformed.

c. ________ strength is the ability of a metal to withstand a force trying to pull the metal apart.

d. ________ metal is metal that contains no iron.

e. ________ metal is metal that contains iron.

3. Write the abbreviation or symbol for each of these words.

a. Alternating current ____________________

b. Angle ____________________

c. Center line ____________________

d. Cold rolled steel ____________________

e. Cubic feet per minute ____________________

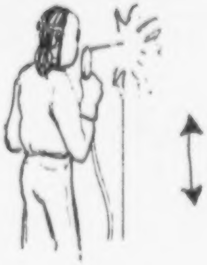
f. Diameter ____________________

g. Direct current ____________________

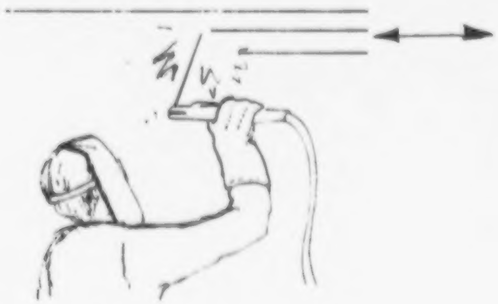
h. Gauge ____________________

4. Here are pictures of welders at work. In the space beneath each picture, write the name of the position shown. The four main welding positions are:

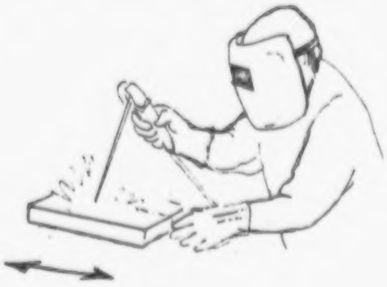
flat horizontal vertical overhead



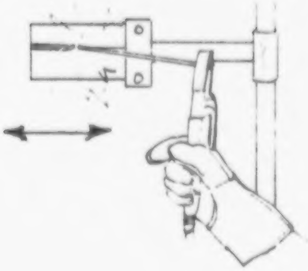
a. __________



b. __________

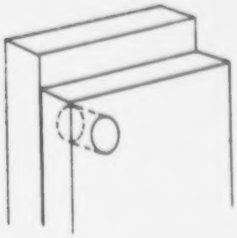


c. __________

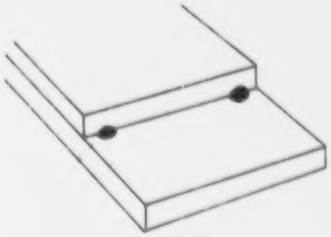


d. __________

5. Here are some special types of welds. In the space beneath each picture, write the name of the weld shown.



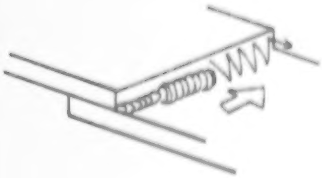
a. ____________

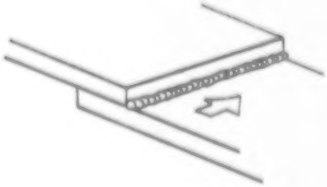


b. ____________

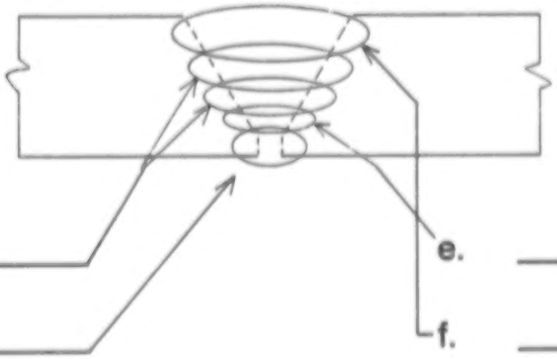
6. Fill in the blanks beside each picture to tell what the picture shows. Use these terms:

- hot pass
- weaving bead
- stringer bead
- cover pass
- filler pass
- root pass





a. ______________________ b. ______________________



c. ______________________

d. ______________________

e. ______________________

f. ______________________

7. Tell two steps you can take to learn new terms.

a. ____

b. ____

8. Tell two steps you can take to help understand and remember better when reading.

a. ____

b. ____

WELDING TERMS

PERFORMANCE CHECKLIST

Student ______________________________ has successfully performed the following:

		Yes	No	Comments
1.	Followed steps for learning terms			
2.	Followed steps for reading material			
3.	Identified and defined basic welding terms			
4.	Identified and defined terms that describe characteristics of metals			
5.	Identified terms that describe welding positions			
6.	Identified terms and uses for special types of welds			
7.	Identified terms that describe types of beads and passes			
8.	Identified common abbreviations used by welders			

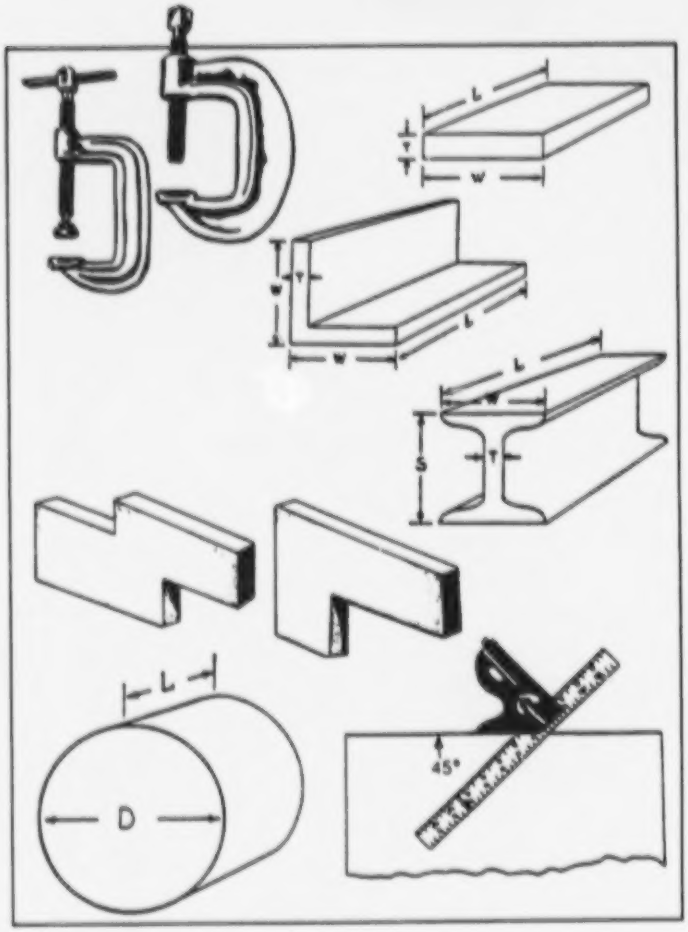
Satisfactory - should move on ☐
Repeat this unit ☐

____________________________ Student's Signature/Date

____________________________ Instructor's Signature/Date

WELDING Supplementary Units

Using Welding References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USING WELDING REFERENCES

INTRODUCTION

Welders use many facts and figures at work. Although welders remember much of the information they use daily, a great deal of information must be looked up in different reference materials.

Reference books provide useful information, while tables and charts help the welder cut, weld, drill, use metals and much more. Because such information is vital to the welder, he or she must know how to find and use reference books, tables and charts.

UNIT OBJECTIVE

After completing this unit, the student should be able to find and use information from reference books, tables and charts.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to specifically:

1. Recognize and use important parts of reference books.
2. List the steps for locating information in reference books.
3. Locate information in reference books.
4. Use reference charts and tables.

ARE YOU READY?

CHECK THE STATEMENT THAT IS TRUE FOR YOU:

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms and Equipment

1. **Appendix** - a part of a reference work, usually placed near the end, that contains extra information.
2. **Chart** - a reference tool that contains information listed in rows and columns. It can also be called a table.
3. **Columns** - the up and down (vertical) lines in a table or chart.
4. **Glossary** - an alphabetical list of terms and their meanings (definitions) usually found at the back of a book.
5. **Index** - an alphabetical list of important subjects covered in a book. The index gives the page numbers where the subjects or terms are mentioned and usually appears at the back of a book.
6. **Reference** - a book or other material that gives helpful information.
7. **Rows** - lines that go from left to right in a table or chart.
8. **Table** - a list of information arranged in order (usually in columns and rows); it can also be called a chart.
9. **Table of contents** - a list of chapters in a book and their beginning page numbers. The table of contents is usually found in the front part of a book.

B. Recognizing and Using the Parts of a Reference Book

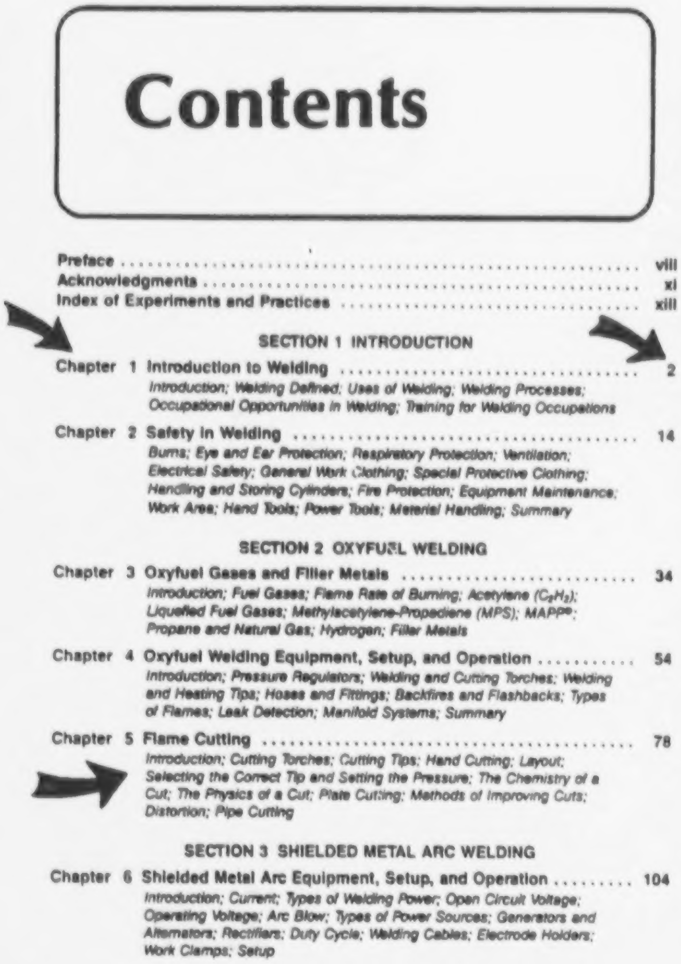
A reference book often includes a table of contents, index, appendix and/or glossary to help you find information in the book quickly and easily. Smaller books may have only a table of contents, while larger books may include all of these parts.

The Table of Contents:

1. You can use the table of contents to find information in a book.

2. The table of contents lists the book's chapters in order and usually gives at least the beginning page number of each chapter.

3. Often a table of contents will list important subjects covered in each chapter. It might also list pictures, charts or other items included in the book.



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Chapter 1 **Introduction to Welding** 2
Introduction; Welding Defined; Uses of Welding; Welding Processes; Occupational Opportunities in Welding; Training for Welding Occupations

Chapter 2 **Safety in Welding** 14
Burns; Eye and Ear Protection; Respiratory Protection; Ventilation; Electrical Safety; General Work Clothing; Special Protective Clothing; Handling and Storing Cylinders; Fire Protection; Equipment Maintenance; Work Area; Hand Tools; Power Tools; Material Handling; Summary

SECTION 2 OXYFUEL WELDING

Chapter 3 **Oxyfuel Gases and Filler Metals** 34
Introduction; Fuel Gases; Flame Rate of Burning; Acetylene (C_2H_2); Liquefied Fuel Gases; Methylacetylene-Propadiene (MPS); MAPP®; Propane and Natural Gas; Hydrogen; Filler Metals

Chapter 4 **Oxyfuel Welding Equipment, Setup, and Operation** 54
Introduction; Pressure Regulators; Welding and Cutting Torches; Welding and Heating Tips; Hoses and Fittings; Backfires and Flashbacks; Types of Flames; Leak Detection; Manifold Systems; Summary

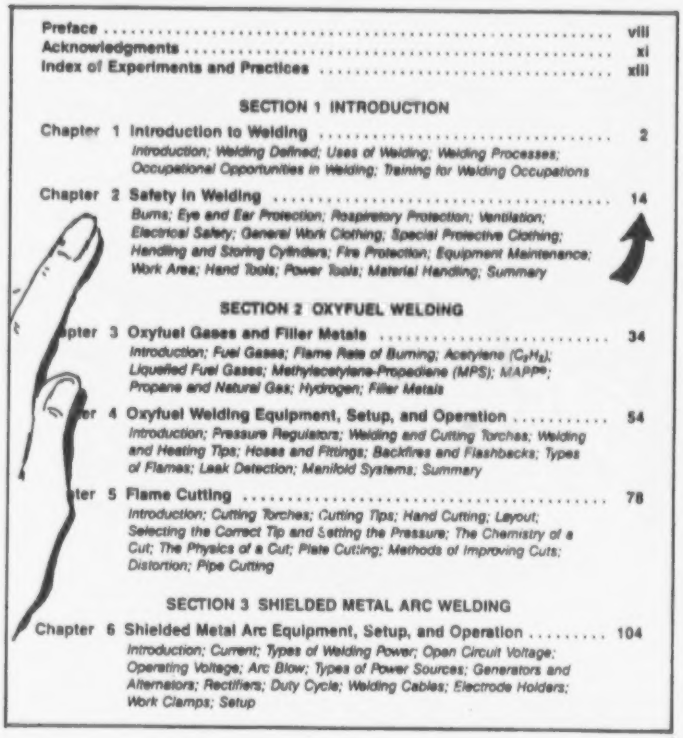
Chapter 5 **Flame Cutting** 78
Introduction; Cutting Torches; Cutting Tips; Hand Cutting; Layout; Selecting the Correct Tip and Setting the Pressure; The Chemistry of a Cut; The Physics of a Cut; Plate Cutting; Methods of Improving Cuts; Distortion; Pipe Cutting

SECTION 3 SHIELDED METAL ARC WELDING

Chapter 6 **Shielded Metal Arc Equipment, Setup, and Operation** 104
Introduction; Current; Types of Welding Power; Open Circuit Voltage; Operating Voltage; Arc Blow; Types of Power Sources; Generators and Alternators; Rectifiers; Duty Cycle; Welding Cables; Electrode Holders; Work Clamps; Setup

4. The table of contents often tells the pages on which a picture or chart can be found.

5. To use the table of contents, skim through the list until you find the item you need. Then turn to the page number the table of contents gives you.



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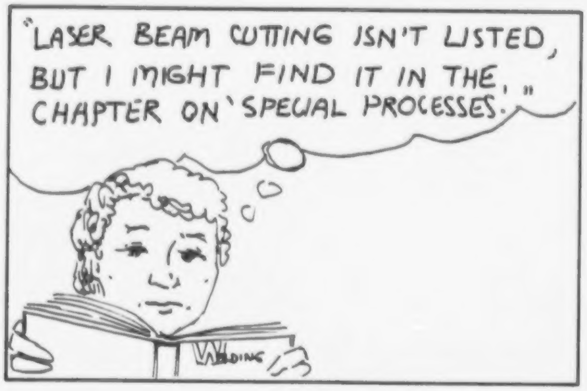
6. Sometimes the item you are looking for might not be listed in the table of contents. In this case, look for the chapter that most likely includes the information you need.


"LASER BEAM CUTTING ISN'T LISTED, BUT I MIGHT FIND IT IN THE CHAPTER ON 'SPECIAL PROCESSES.'"
WELDING

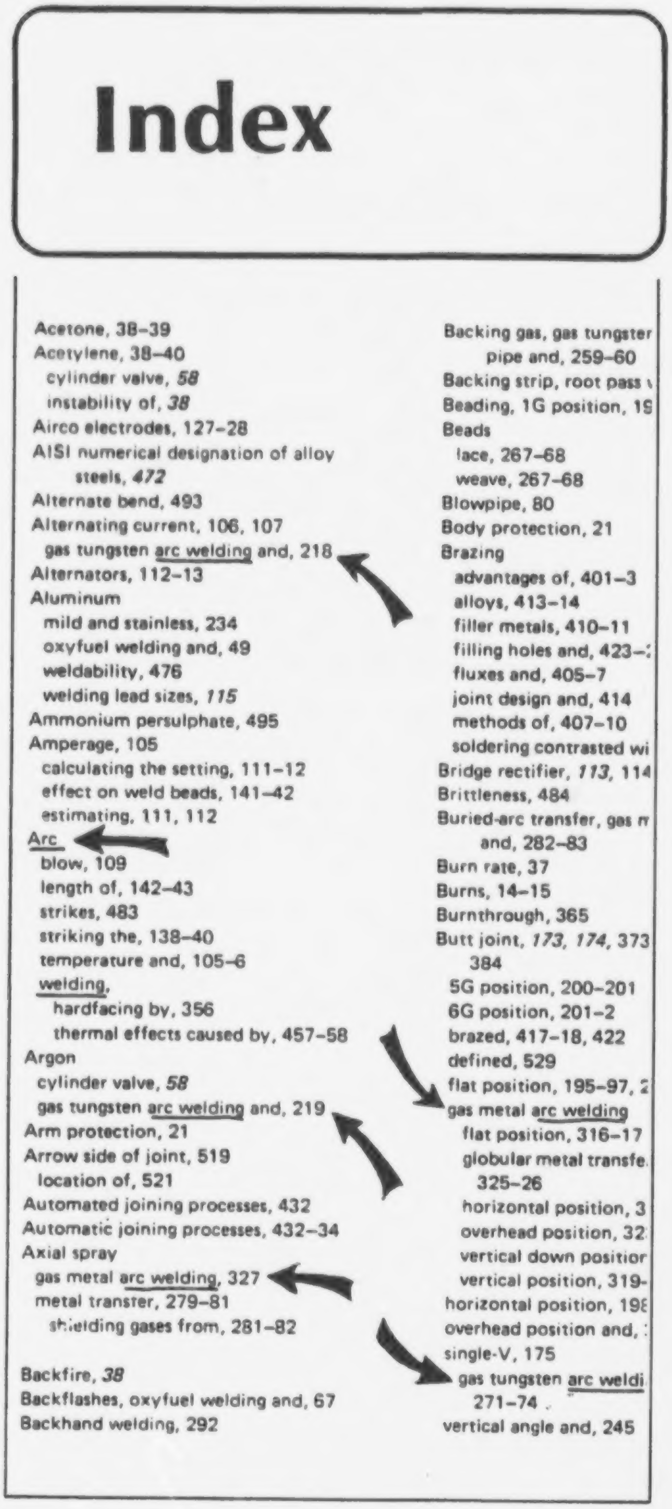
The Index

7. Use the index to find information in a book.

8. The index lists subjects covered in a book and tells the page or pages on which the subject is mentioned.

   In the index, subjects are listed in alphabetical order.

9. To use the index, decide on the word or words that best describe the information you want to find.



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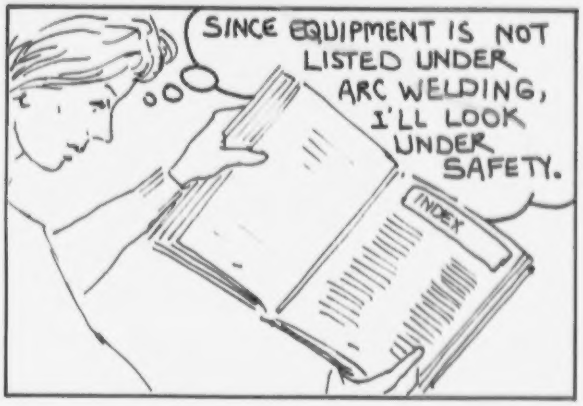
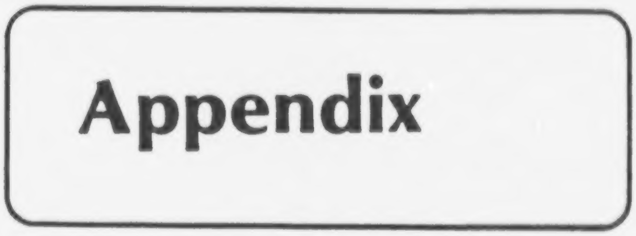
10. Looking through the listings, which are in alphabetical order, find the word or words that best describe your subject. Then turn to the page indicated.

Sometimes you will need to think of several related words and look for them before you find the subject you want.

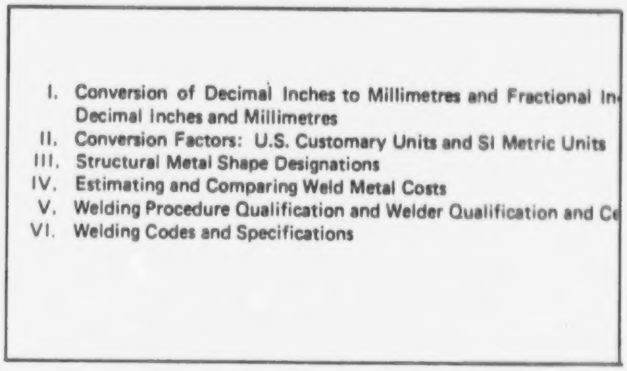

SINCE EQUIPMENT IS NOT LISTED UNDER ARC WELDING, I'LL LOOK UNDER SAFETY.
INDEX

The Appendix

11. An appendix contains extra information added at the back of the book. Usually an appendix includes helpful information that does not fit into the chapters of the book.



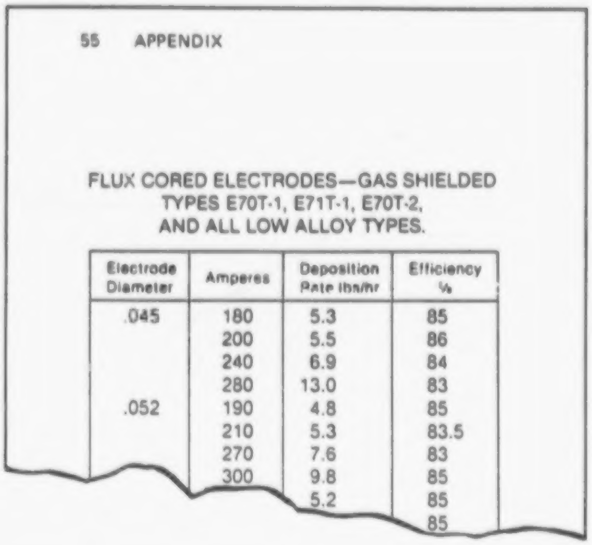
Appendix



I. Conversion of Decimal Inches to Millimetres and Fractional In
Decimal Inches and Millimetres
II. Conversion Factors: U.S. Customary Units and SI Metric Units
III. Structural Metal Shape Designations
IV. Estimating and Comparing Weld Metal Costs
V. Welding Procedure Qualification and Welder Qualification and Ce
VI. Welding Codes and Specifications

12. An appendix might have information such as abbreviations, types of measurement or tables that show how to convert from one measurement to another.

13. Information in an appendix is often shown in the form of a list, chart or table.



55 APPENDIX

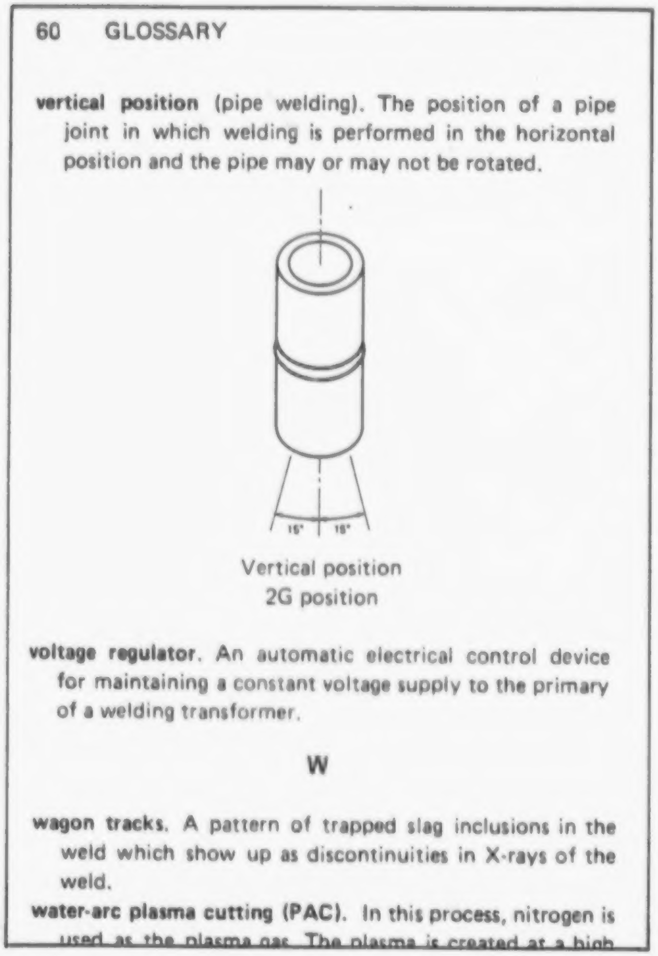
FLUX CORED ELECTRODES—GAS SHIELDED
TYPES E70T-1, E71T-1, E70T-2,
AND ALL LOW ALLOY TYPES.

Electrode Diameter	Amperes	Deposition Rate lbs/hr	Efficiency %
.045	180	5.3	85
	200	5.5	86
	240	6.9	84
	280	13.0	83
.052	190	4.8	85
	210	5.3	83.5
	270	7.6	83
	300	9.8	85
		5.2	85
			85

The Glossary

14. Some books also have a glossary at the end of the book. A glossary is an alphabetical list of terms and their meanings (definitions).

A glossary for a welding book might include the meanings of difficult terms used in the book or used by welders.



60 GLOSSARY

vertical position (pipe welding). The position of a pipe joint in which welding is performed in the horizontal position and the pipe may or may not be rotated.

Vertical position
2G position

voltage regulator. An automatic electrical control device for maintaining a constant voltage supply to the primary of a welding transformer.

W

wagon tracks. A pattern of trapped slag inclusions in the weld which show up as discontinuities in X-rays of the weld.

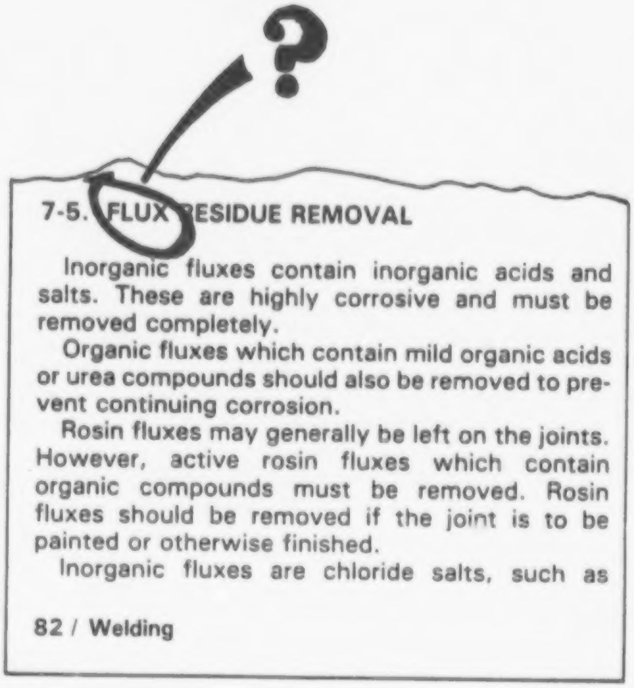
water-arc plasma cutting (PAC). In this process, nitrogen is used as the plasma gas. The plasma is created at a high

15. When using a reference book, you may find words you do not recognize or understand.

If you look up these words in a glossary or in the dictionary, you will understand them better and begin to use them without thinking.

(NOTE: If your textbook does not have a glossary, you might want to ask your instructor to recommend a good technical dictionary for welding.

A paperback welding dictionary or book of terms would be less expensive than a large dictionary.)



7-5. FLUX RESIDUE REMOVAL

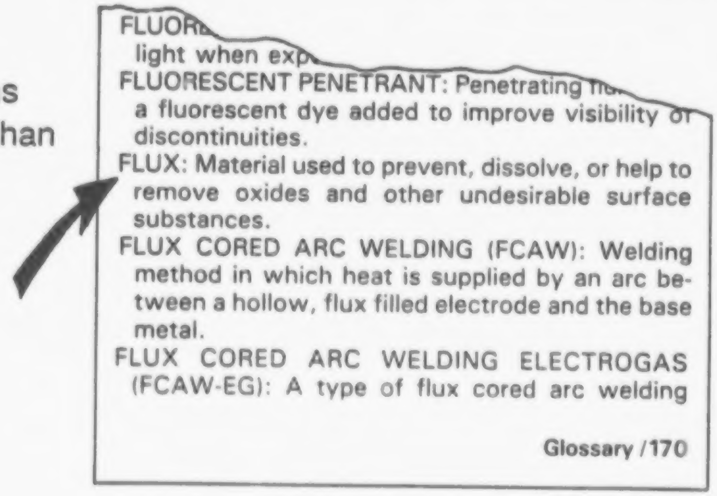
Inorganic fluxes contain inorganic acids and salts. These are highly corrosive and must be removed completely.

Organic fluxes which contain mild organic acids or urea compounds should also be removed to prevent continuing corrosion.

Rosin fluxes may generally be left on the joints. However, active rosin fluxes which contain organic compounds must be removed. Rosin fluxes should be removed if the joint is to be painted or otherwise finished.

Inorganic fluxes are chloride salts, such as

82 / Welding



FLUOR
light when exp
FLUORESCENT PENETRANT: Penetrating
a fluorescent dye added to improve visibility of discontinuities.

FLUX: Material used to prevent, dissolve, or help to remove oxides and other undesirable surface substances.

FLUX CORED ARC WELDING (FCAW): Welding method in which heat is supplied by an arc between a hollow, flux filled electrode and the base metal.

FLUX CORED ARC WELDING ELECTROGAS (FCAW-EG): A type of flux cored arc welding

Glossary / 170

DO SKILL SHEET 1
DO ACTIVITY SHEET 1

SKILL SHEET 1

RECOGNIZING PARTS OF REFERENCE BOOKS

Directions: Answer the questions below by telling what part of a reference book is most helpful in the situation given. The parts of a book are listed for you and may be used more than once.

index	glossary	table of contents	appendix

1. Where should you look to find a list of the chapters in a book?

____

2. Where should you look in a reference to find the meaning of a new term?

____

3. Where can you look to find extra information not covered in the main part of the book?

____

4. Where would you look in a book to find the page on which a particular subject is discussed?

____

5. Which part of the book lists items in the order they appear in the book?

____

6. Which two parts of a book usually list things in alphabetical order?

____

____

7. Which part of a book is like a small dictionary?

____

8. Which two parts of a book tell where things can be found in the book?

____

____

ACTIVITY SHEET 1

USING PARTS OF REFERENCE BOOKS

Directions: Using a welding reference book or textbook provided by your instructor, answer the questions below. You will need to use what you have learned about the parts of reference books to help you find the answers. If you answer "yes" to a question, write the number of the page on which that part or information can be found in the book.

1. Does the book have a chapter on "safety"? ______________________

2. Does the book have a chapter on "metallurgy" (could also be called "metal technology" or "the properties of metals")? ________________

3. Is there information in the book on "robots"? ____________________

4. Is there information in the book on "codes and standards"? ________

5. Does the book have a glossary? ______________________________

6. Does the book have more than one index? _______ If your answer is "yes," tell what kinds of indexes are in the book.

____

____

7. Does the book have an appendix? ____________________

If your answer is "yes," tell what kind of information is in the appendix.

____

____

8. Do you think the book is arranged so it is easy to use? ____
If your answer is "no," tell how the book could be improved.
If your answer is "yes," tell what part of the book you find most helpful and why.

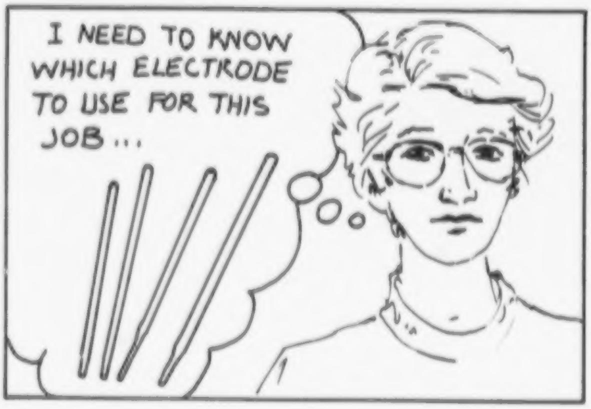
____

____

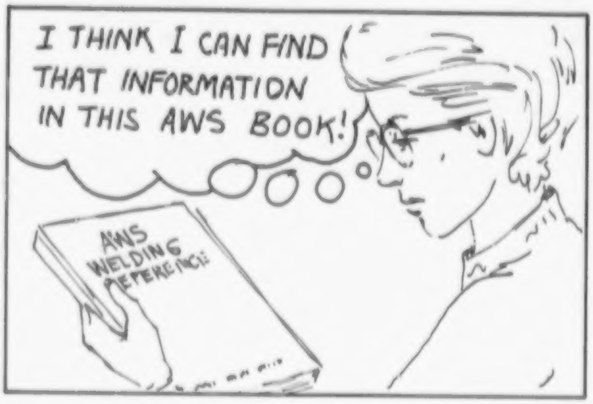
____

C. Five Steps for Using References

1. Decide what information you need.

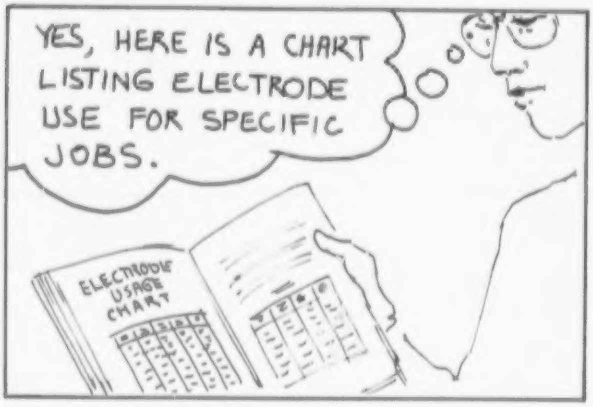

I NEED TO KNOW WHICH ELECTRODE TO USE FOR THIS JOB...

2. Decide which reference is likely to contain the information you need.


I THINK I CAN FIND THAT INFORMATION IN THIS AWS BOOK!
AWS WELDING REFERENCE

3. Look up the information in the reference.

4. Read the information.


YES, HERE IS A CHART LISTING ELECTRODE USE FOR SPECIFIC JOBS.
ELECTRODE USAGE CHART

5. Apply the information to the job being done.

D. Following the Five Steps for Using References

Here's an example that shows how the five steps for using references can be followed to find and use helpful information.

Don is getting ready to cut 1/2-inch mild steel plate with an oxyacetylene cutting torch that uses a number 2 tip. The torch's brand name is "XYZ," which Don has never used before. Don knows from past experience that different brands of torches require different oxygen and acetylene pressure settings. Because he does not know the pressure settings for this torch, he will have to use reference materials to find the information.

Let's follow Don through the five steps of using a reference to locate the information he needs.

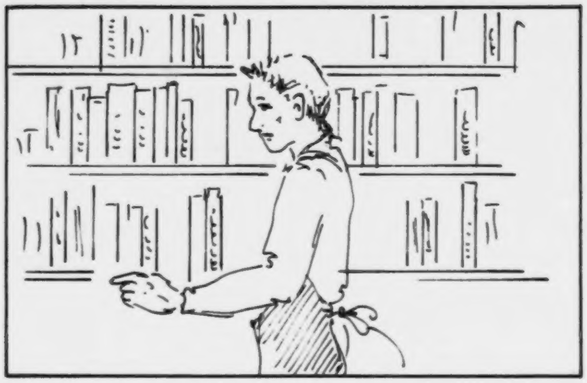
1. Decide what information is needed.

   Don needs to know the oxygen and acetylene pressure settings for cutting 1/2-inch mild steel with an XYZ brand cutting torch and a number 2 cutting tip.

2. Decide which reference is likely to contain the information you need.

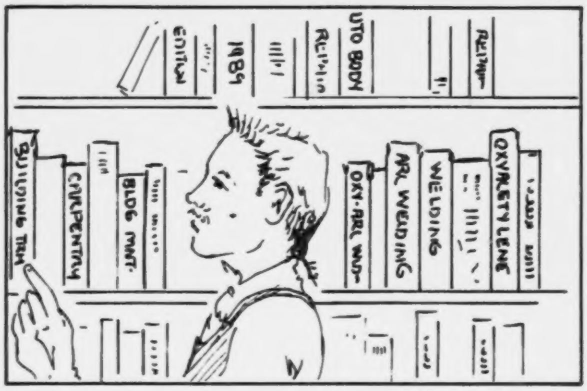
   Many shop references are available, but Don does not have time to look through all of them. He must eliminate references that are not likely to contain the information he needs.

Here is how Don decides which reference he wants:



- First, Don eliminates all the references that do not deal with welding.

  (He gets rid of a carpentry reference because it probably does not contain information on oxyacetylene welding.)

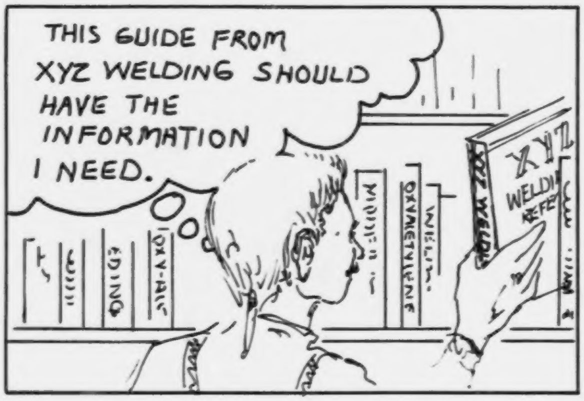

EDITION
1989
REPAIR
UTO BODY
REPAIR
WELDING TECH
CARPENTRY
BLDG MAINT.
OXY-ARC WLD
ARC WELDING
WELDING
OXYACETYLENE

- Second, Don eliminates all references that do not deal with oxyacetylene cutting.

  (He puts back an arc welding reference because it probably does not contain information on oxyacetylene cutting.)

- Third, Don eliminates all references that do not cover oxyacetylene cutting with an XYZ brand cutting torch.

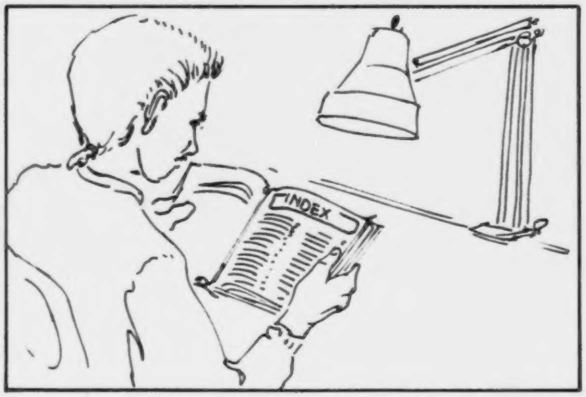
  (He passes over a general welding textbook because it is not likely to contain information on a specific brand (XYZ) of torch.)


THIS GUIDE FROM XYZ WELDING SHOULD HAVE THE INFORMATION I NEED.
XYZ
WELDI
REFE
XYZ WELDI
OXYACETYLENE
OXY-ARC

By the time he has finished the process, Don has narrowed his choices so he can decide on a reference that most likely contains the needed information.

3. Look up the information in the reference.

   - Don does not have time to look through the entire reference to find the information he wants. He must find the information quickly so he can get on with the cutting job.



   - In this case, the best way to find information quickly is to use the index. Don looks up "cutting pressures" in the index to find the page that mentions the needed information.

   - Don turns to the page indicated in the index and finds a chart with the information he needs.

CUTTING PRESSURE FOR XYZ BRAND CUTTING TORCH

Metal Thickness	Tip Size	Tip Cleaner #	Oxygen Pressure	Acetylene Pressure
1/8 inch	0	2	10	3
1/4 inch	1	3	15	3
3/8 inch	1	3	20	4
1/2 inch	2	4	25	5
3/4 inch	2	4	30	5
1 inch	3	4	35	5

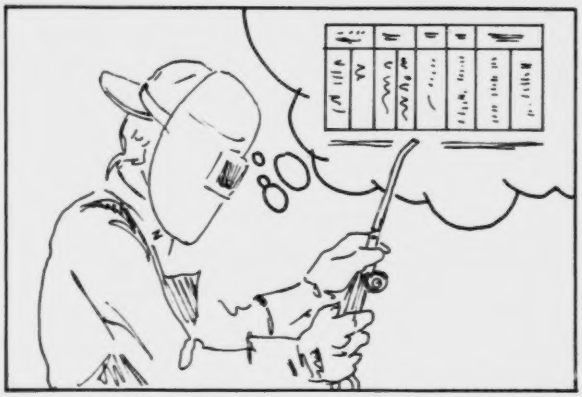
4. Read the information.

   Don reads the chart to find the necessary information.

Metal Thickness	Tip Size	Tip Cleaner #	Oxygen Pressure	Acetylene Pressure
1/8 inch	0	2	10	3
1/4 inch	1	3	15	3
3/8 inch	1	3	20	4
1/2 inch	2	4	25	5
3/4 inch	2	4	30	5
1 inch	3	4	35	5

5. Apply the information to the job being done.

   Now Don knows the right pressures to use with this XYZ brand cutting torch to cut 1/2-inch mild steel. He can set the pressures and do the job.



6. Now you have seen an example of how to use a reference. If you can follow these steps when using reference materials, you will be a better welder.

7. Remember the steps:
   a. Decide what information is needed.
   b. Decide which reference is likely to contain the information needed.
   c. Look up the information in the reference.
   d. Read the information.
   e. Apply the information to the job being done.

DO SKILL SHEET 2

DO ACTIVITY SHEET 2

SKILL SHEET 2

FINDING USEFUL REFERENCES

Directions: Below is a list of the steps to follow in finding and using reference information, but the list is out of order. Write the list over again in the correct order.

Look up the information in the reference.

Decide which reference is likely to contain the information.

Apply the information to the job being done.

Decide what information you need.

Read the information.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

ACTIVITY SHEET 2

FINDING INFORMATION IN REFERENCES

Directions: Using reference materials in your class or school, find the answers to the following questions. Write the answers in the spaces provided.

1. For the best eye protection, which lens shade number is recommended for gas metal arc welding of ferrous metals?

   ____

2. What is the abbreviation for chromium?

   ____

3. What is the melting temperature of aluminum in degrees Fahrenheit? In degrees Centigrade?

   ____

4. Tell what an element is and give an example of an element.

   ____

   ____

5. Name two metals that release dangerous fumes when melted.

   ____

6. Name the four different size marking systems used for drill bits.

   ____

D. Steps of Procedure for Using Charts and Tables

Much of the information a welder needs is printed in tables. Because they list information in rows and columns, tables are an efficient way of showing many bits of information in a small amount of space. A welder must know how to interpret this information.

1. Charts and tables show information listed in rows (across) and columns (up and down).

   - Each row has a title or heading to tell what information the row contains.

CUTTING PRESSURE FOR XYZ BRAND CUTTING TORCH

Metal Thickness	Tip Size	Tip Cleaner #	Oxygen Pressure	Acetylene Pressure
1/8 inch	0	2	10	3
1/4 inch	1	3	15	3
3/8 inch	1	3	20	4
1/2 inch	2	4	25	5
3/4 inch	2	4	30	5
1 inch	3	4	35	5

   - Each column has a title or heading to tell what information the column contains.

Metal Thickness	Tip Size	Tip Cleaner #	Oxygen Pressure	Acetylene Pressure
1/8 inch	0	2	10	3
1/4 inch	1	3	15	3
3/8 inch	1	3	20	4
1/2 inch	2	4	25	5
3/4 inch	2	4	30	5
1 inch	3	4	35	5

2. To find information on a chart or table:

   - Find the row with the heading for the type of information you need.

Metal Thickness	Tip Size	Tip Cleaner #	Oxygen Pressure	Acetylene Pressure
1/8 inch	0	2	10	3
1/4 inch	1	3	15	3
3/8 inch	1	3	20	4
1/2 inch	2	4	25	5
3/4 inch	2	4	30	5
1 inch	3	4	35	5

- Using your finger or a ruler, follow the row across the page until you come to the column you need.

  (Look at the heading to be sure you have the column for the type of information you need.)

Metal Thickness	Tip Size	Tip Cleaner #	Oxygen Pressure	Acetylene Pressure
1/8 inch	0	2	10	3
1/4 inch	1	3	15	3
3/8 inch	1	3	20	4
1/2 inch	2	4	25	5
3/4 inch	2	4	30	5
1 inch	3	4	35	5

The welder now has the information needed to cut the 1/2-inch mild steel using a number 2 tip on an XYZ brand cutting torch.

DO SKILL SHEETS 3 AND 4

SKILL SHEET 3

Directions: Use the reference chart below to answer each question in the space provided.

WELDING TIPS - Oxygen and Acetylene

Metal Thickness	WELDING TIP	Drill Size	ACETYLENE & OXYGEN	
			Pressure Each Gas (PSIG) At Reg.	Consumption Each Gas (SCFH)
Very Light Metal up to 1/32"	AW2000 AW200 AW20 AW201	78	10	.65
		76	10	1.3
		74	10	1.7
		71	10	2.3
		69	10	3.0
1/16" to 3/32"	AW202	67	10	3.2
	AW203	63	10	4.3
	AW204	57	10	6.
1/8"	AW205	56	10	9
5/32"	AW206	54	10	12
3/16"	AW207	52	10	17
1/4"	AW208	49	10	23
3/8"	AW209	44	11	36
1/2"	AW210	40	11	49

Chart: Smith Equipment. A Division of Testcom Co.

1. Which welding tip would you use to weld metal that is 1/8" thick?

____

2. Which drill size would you use to recondition an AW210 tip?

____

3. Which oxygen and acetylene pressures would you use to weld 1/16" metal with an AW202 tip?

____

4. Which tip would you select in order to weld metal that is 3/16" thick?

____

5. Which oxygen and acetylene pressures would you use to weld 3/8" thick metal?

____

UNIT REVIEW

Directions: Fill in the blanks with the term that best completes each sentence. A list of terms is provided below.

appendix
index
column
rows
table of contents
glossary

1. A list of chapters is shown at the front of a book, in the

   ______________________________.

2. If you want to know what a word means, you can look it up in

   the ____________________.

3. Helpful extra information can be found in the ______________________________, which is found at the back of the book.

4. To quickly find where information is located in a book, you

   can look up the subject in the __________,

   which is at the back of the book.

5. Lines in a table or chart that go from left to right are called ______________________________.

6. Lines in a table or chart that go up and down are called ______________________________.

7. Directions: Below is a list of the steps to follow in finding and using reference information, but the list is out of order. Show the correct order of the steps by writing "1" beside the first step, "2" beside the second step, and so on.

a. _____ Look up the information in the reference.
b. _____ Decide which reference is likely to contain the information.
c. _____ Apply the information to the job being done.
d. _____ Decide what information you need.
e. _____ Read the information.

PERFORMANCE CHECKLIST

Student ______________________________ successfully performed the following tasks:

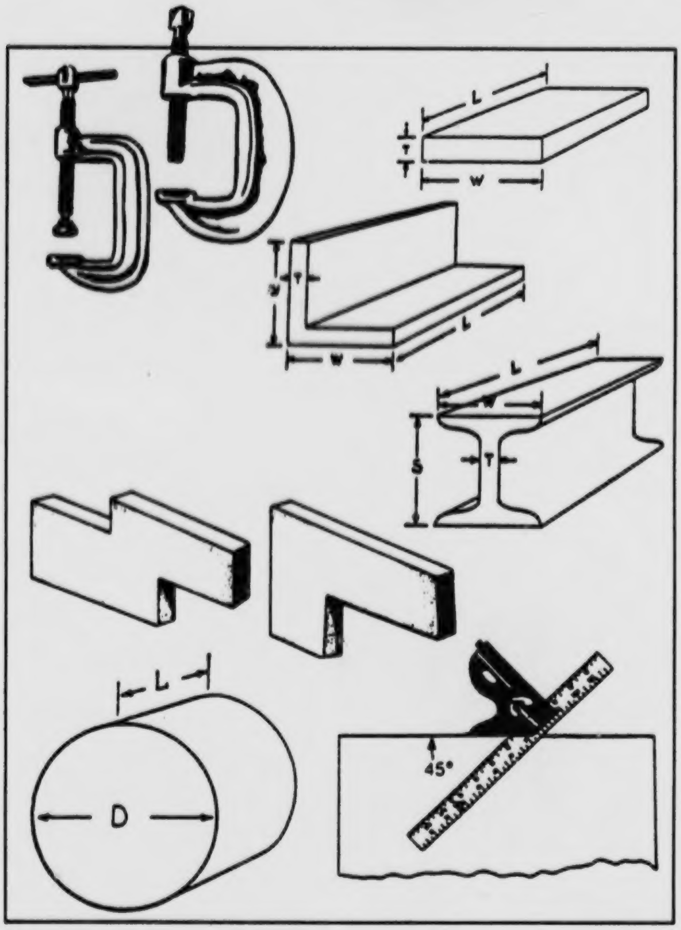
	Yes	No	Comments
1. Recognized and used important parts of reference books.			
a. Table of Contents			
b. Index			
c. Appendix			
d. Glossary/Dictionary			
2. Located information in reference books.			
a. Decided what information was needed.			
b. Decided which reference might contain needed infomation.			
c. Looked up information in the reference.			
d. Read the information.			
e. Applied the information.			
3. Used reference charts and tables to find the information.			

Satisfactory - should move on ☐
Should repeat this unit ☐

____
Student's Signature/Date

____
Instructor's Signature/Date

WELDING Supplementary Units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General Safety Procedures

GENERAL SAFETY PROCEDURES

INTRODUCTION

The ability to work safely is the most important skill a welder can develop. The old saying, "An ounce of prevention is worth a pound of cure," is especially true for welders, because welders need to prevent accidents to protect themselves and their co-workers as well. A few minutes spent fixing a safety hazard may save a month or more of recovery from an accident. Always remember the slogan -- "Safety first, safety last and safety always."

UNIT OBJECTIVES

After completing this unit, you will be able to identify common safety hazards and be able to list the steps necessary to eliminate them.

Specific Objectives

After completing this unit you should be able to specifically:

1. Select safe welding clothing.
2. Understand and follow shop safety rules.
3. Identify and use fire extinguishers.
4. Identify and correct hazards caused by poor ventilation.
5. Safely store and handle cylinders.
6. Follow oxyacetylene and arc welding safety rules.

ARE YOU READY?

CHECK THE STATEMENT THAT IS TRUE FOR YOU:

☐ **I can do these tasks and want to go through the Performance Checklist.**

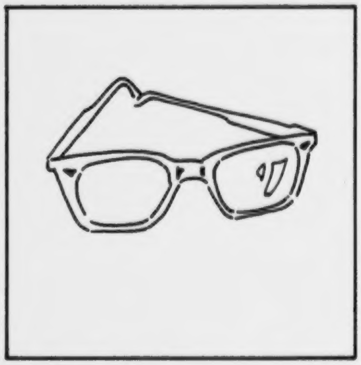
SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

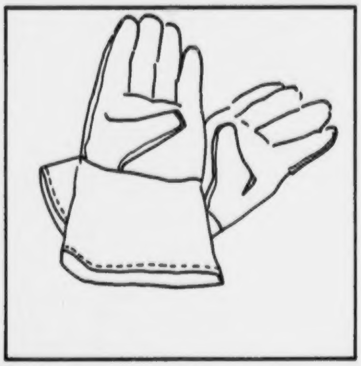
TURN PAGE AND BEGIN

A. Terms and Equipment for General Welding Safety

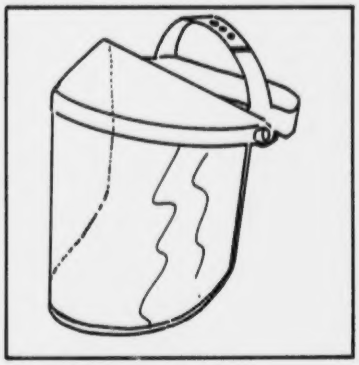
Equipment



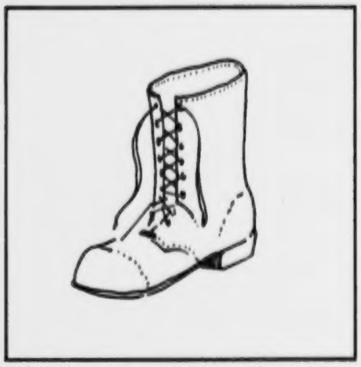
Safety glasses



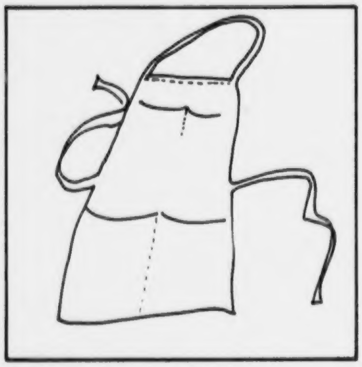
Full safety gloves



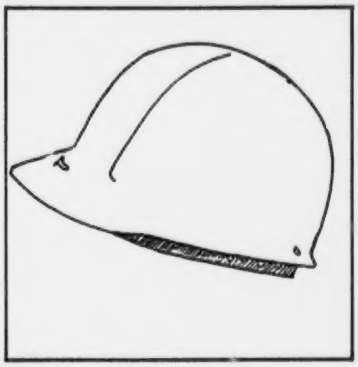
Full face shield



Steel-toed safety boots

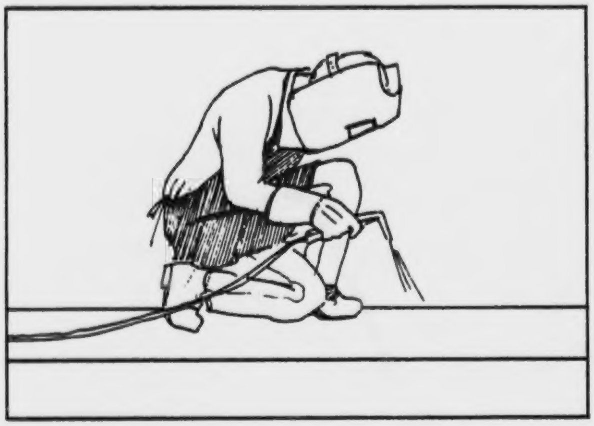


Shop apron

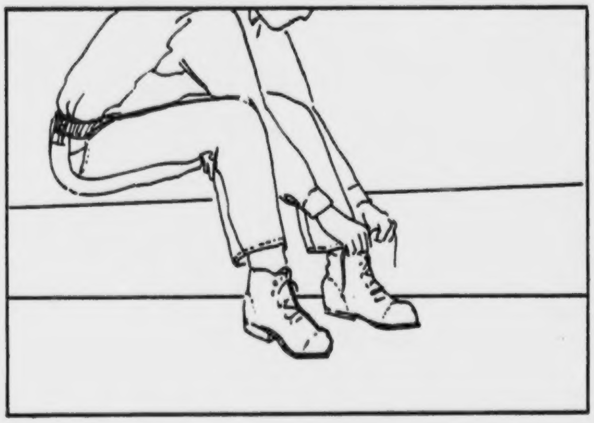


Hard hat

B. Wearing Proper Clothing and Safety Equipment



1. Always wear proper clothing and safety equipment on the job.



2. A welder should always wear heavy work boots. These boots protect the welder's feet from falling sparks, hot metal and other objects. Often welders are required to wear steel-toed boots, which provide extra protection for the welder's feet.

   CAUTION: Never wear tennis shoes, sandals or other shoes that do not protect feet properly from falling objects, sparks, fire or molten metals. Protect your feet carefully because they can be easily smashed or burned.

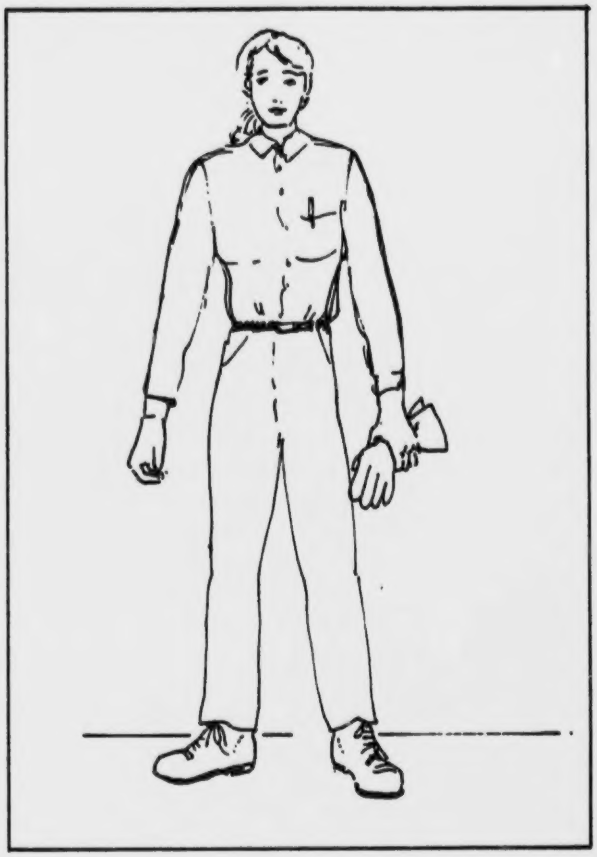
3. Proper clothing must be worn in the welding shop.

   Clothes should be made of wool or treated cotton because these fabrics are less flammable than other materials.

   Clothes should not be torn, frayed or greasy because marred clothing surfaces catch fire more quickly.

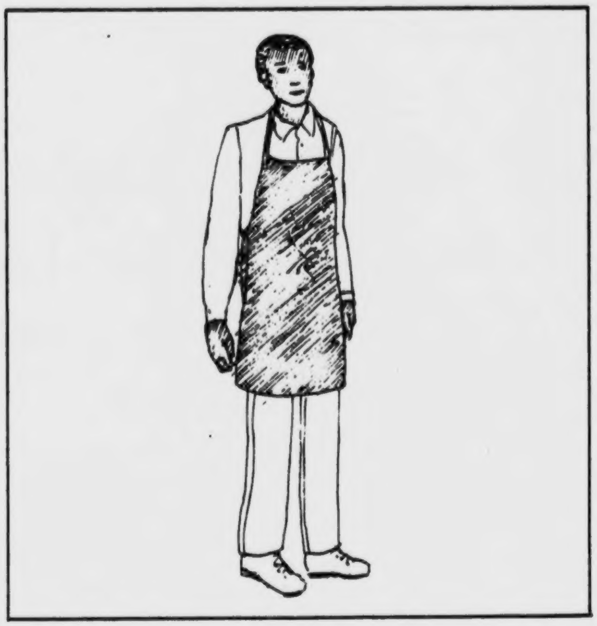
   Welders should wear long-sleeved shirts and cuffless pants that protect skin and cannot catch stray sparks or hot metal. The shirt should always be tucked into the pants and always be buttoned at the neck.

   CAUTION: Never wear knit or polyester clothing. These materials catch fire easily and burn rapidly.



4. Welders must also wear proper outer protective clothing, usually a leather or treated cotton shop apron.

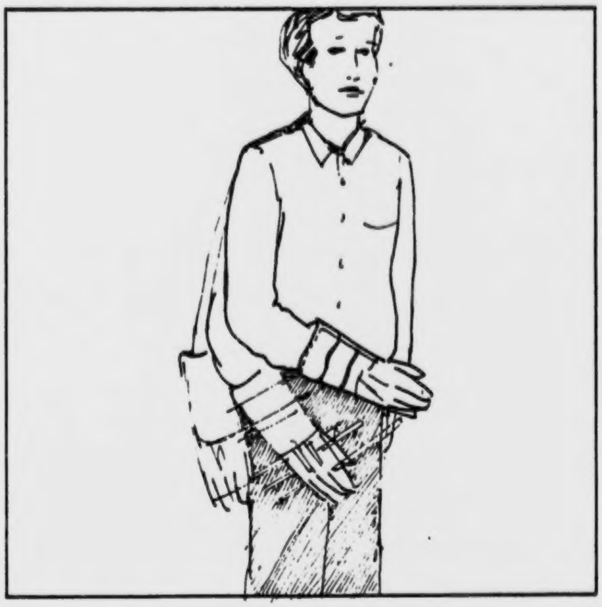
   (In some cases, the welder may wear leather chaps and a leather jacket instead.)



Make sure all apron or jacket pockets are closed to prevent a hot spark from falling into a pocket and starting a fire.

NOTE: Remember, protective outer clothing gives you another layer of protection from hot metal. This extra layer may prevent a serious burn.

5. Welders must also wear insulated leather gloves, which protect the welder from burns and electrical shock.

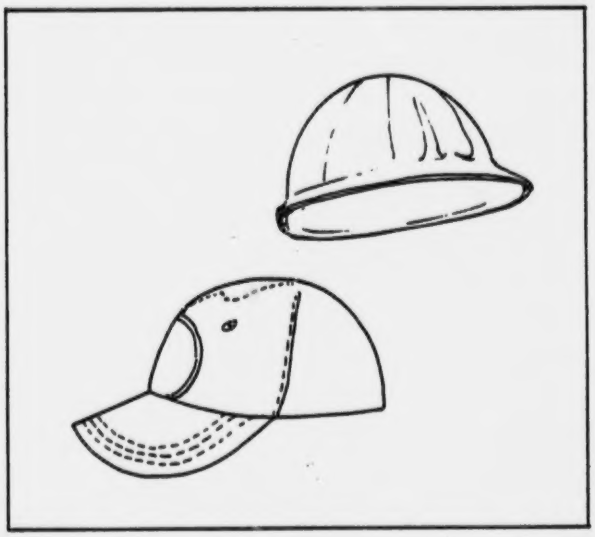


Gloves should fit tightly enough to be easy to work in, but not so tight that they cannot be taken off quickly.

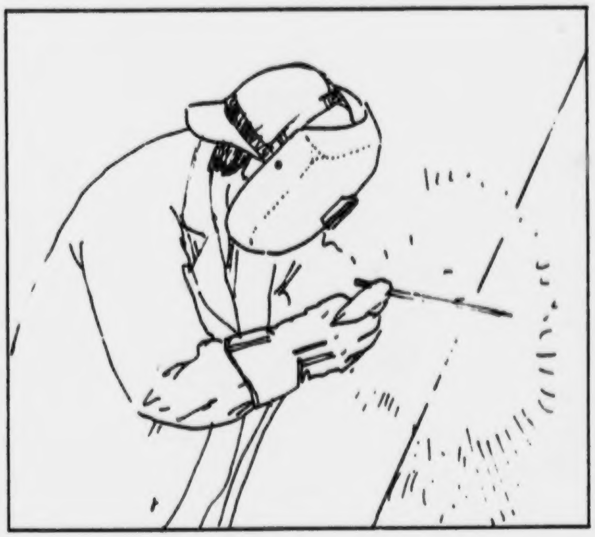
NOTE: To check if your gloves are too tight, put on one of your gloves and hold your hand in front of your face. Quickly swing your arm downward. If the glove does not come off, it is too tight.

6. Proper head, face and eye protection is also important to the safety of the welder.

7. Head protection varies from shop to shop. Some shops require a treated cotton welding cap to protect the scalp from burns. Other shops require hard hats, which protect welders from burns and falling objects.



8. Because a welder's face must be protected from the electric arc welder's rays, the welding helmet covers the entire face. The helmet blocks the rays and prevents "arc burns."



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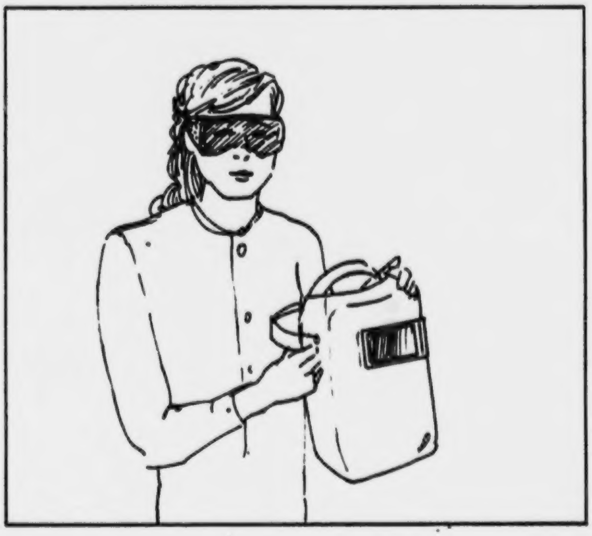
9. The filter lens in the welding helmet protects your eyes. Never arc weld without the lens in place.

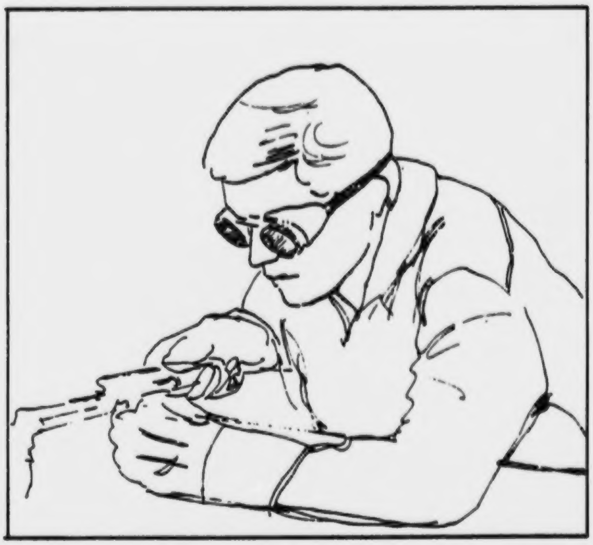
   Always make sure the filter lens is dark enough for the work you are doing. If you are unsure about the filter you need, ask your teacher or supervisor.



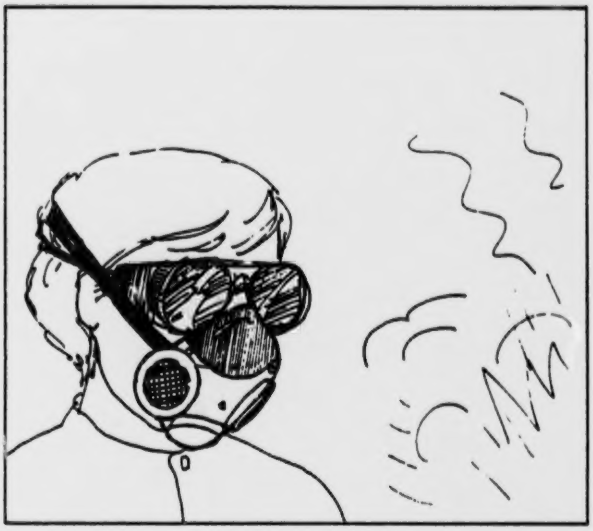
10. Eye protection is very important, even for those not welding at the moment.

    The welder must wear protective safety glasses or goggles at all times in the welding shop, even when a welding helmet covers the face.

    NOTE: Safety glasses must be equipped with approved sideshields. Always wear safety goggles or safety glasses when in the welding shop.



11. Your employer may want you to wear additional safety equipment. This additional safety equipment might include ear muffs, respirators, etc.



12. Remember, "Safety first, safety last, and safety always."

Do Activity Sheet 1.

ACTIVITY SHEET 1

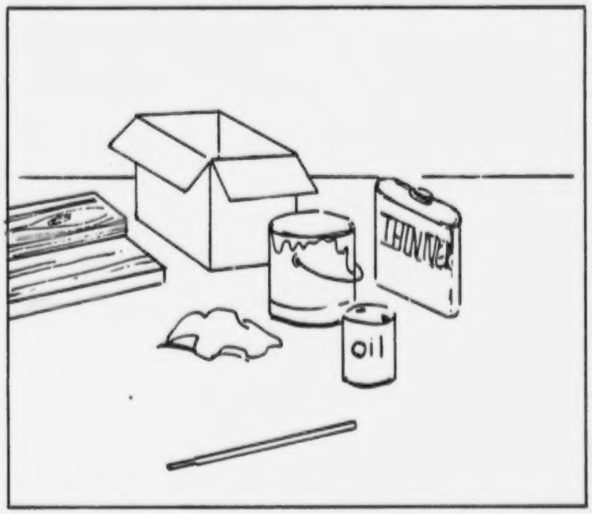
Go to the welding shop. Identify as many safety items as you can. List the name of each safety item and write how it can protect you.

C. Following Shop Safety Procedures

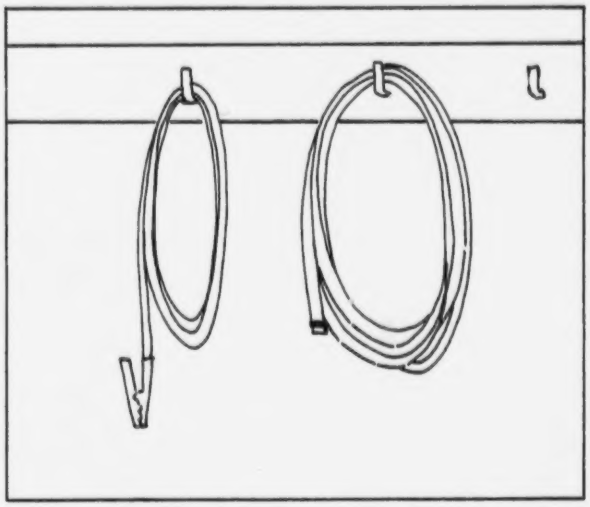
1. Specific safety procedures will change from one shop to the next. But some procedures will always be the same, no matter what shop you work in.

2. A "flammable" is anything that will burn in a fire. Remove flammables, such as paper, cardboard, rags, paint, thinners and oils, from your work area before welding.

3. Make sure the floor is clean and clear of objects that you can fall or stumble over. Always keep the floor clear of scraps and trash.



4. Keep all hoses and cables that are not in use hung up and neatly coiled. Storing them away neatly will prevent you from tripping over them and will keep the hoses and cables from being damaged. When damaged, they may cause a fire or an electrical shock.

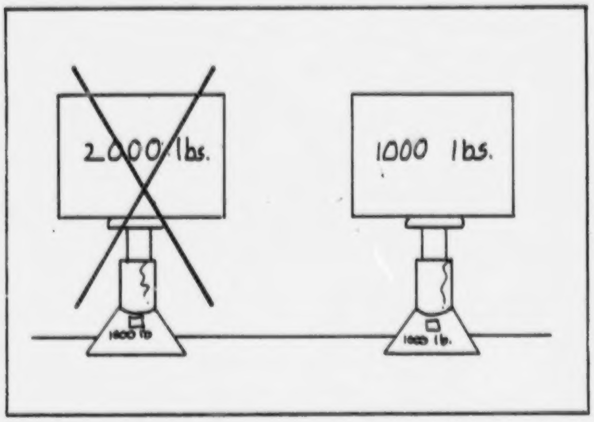


5. Always lift or move heavy objects safely.

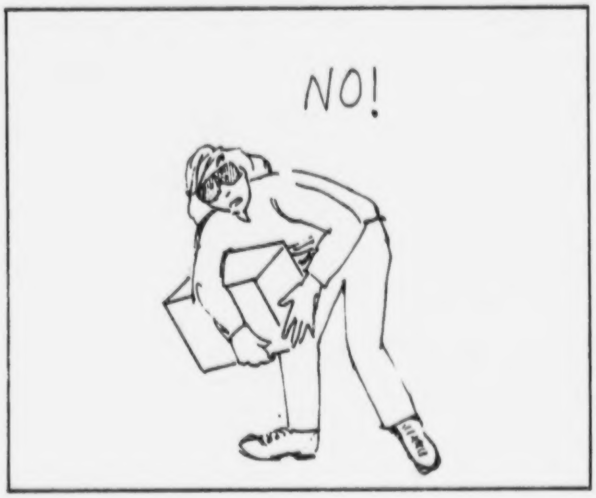
6. Make sure the object is not too heavy for you.

   If you are using a lifting device, (hoist, jack, etc.) make sure the object is not too heavy for the lifting device.

   (The lifting device's weight limit will be stamped on it.)

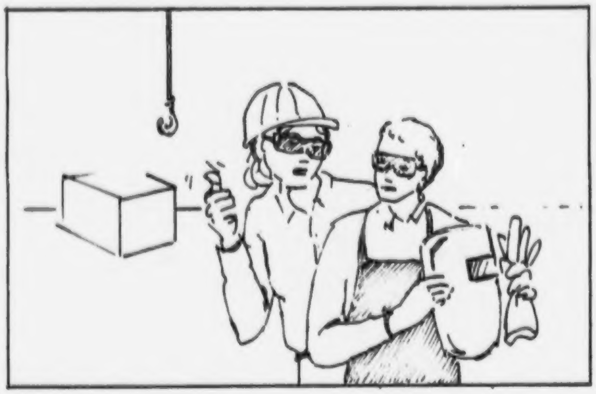

2000 lbs.
1000 lbs.
1000 lb
1000 lb.

7. Make sure you have a good grip on the object before you try to lift it. If you are using a lifting device, make sure the object is fastened securely.

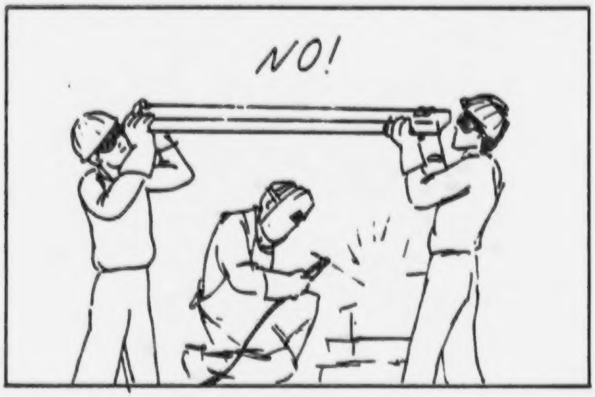


8. Always lift with your legs, not with your back.

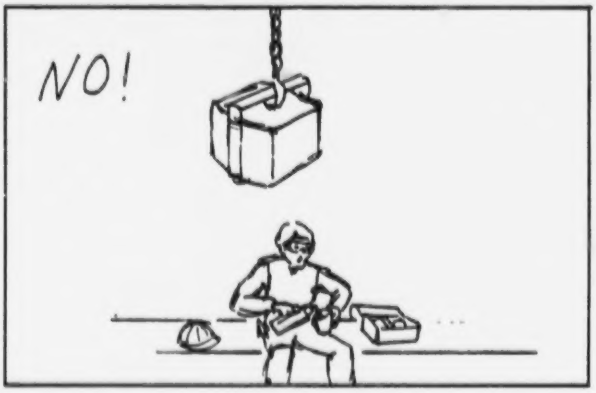
9. Always tell other workers in the area before you move an object.



10. Never lift an object over another person. Ask him or her to move out of the way before you move the object.



11. Never stand or walk under a heavy object that has been lifted from its normal position unless it has been properly secured.



12. Always notify your supervisor of any safety hazard that you are not qualified to fix.

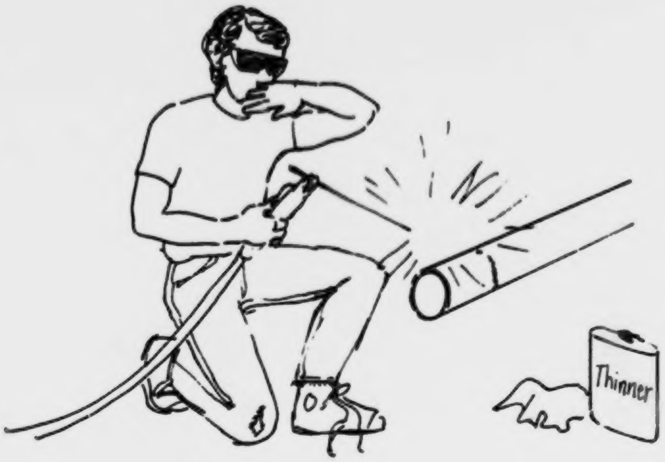
Do Skill Sheet 1.

SKILL SHEET 1

1. List the proper clothing to wear in a welding shop to protect each body part listed below.

   a. feet ______________________________
   b. eyes ______________________________
   c. body ______________________________
   d. hands ______________________________
   e. face ______________________________

2. List all of the safety violations you can find in the illustration below.

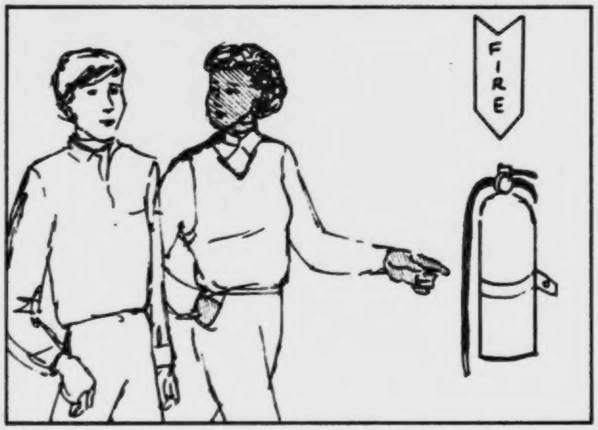


1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________

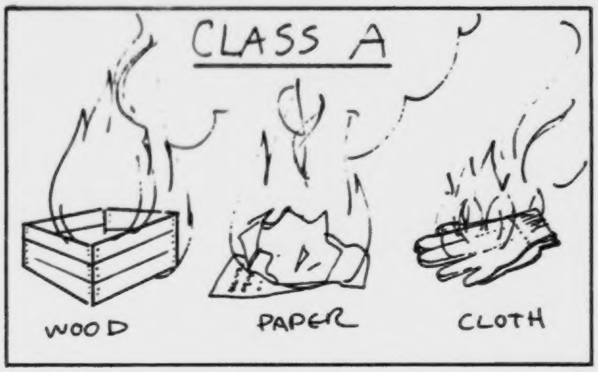
D. Classifying Types of Fires and Selecting Fire Extinguishers

1. When you first begin working in a shop, you should always locate the fire extinguishers.

   Many shops have signs that tell where fire extinguishers are located. If your shop has no signs, ask your supervisor to show you where the fire extinguishers are.

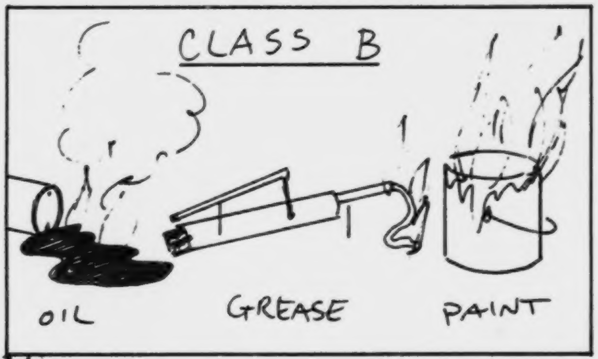


2. Fires are classified according to the type of material that is burning. There are four classes of fires: "A," "B," "C" and "D."

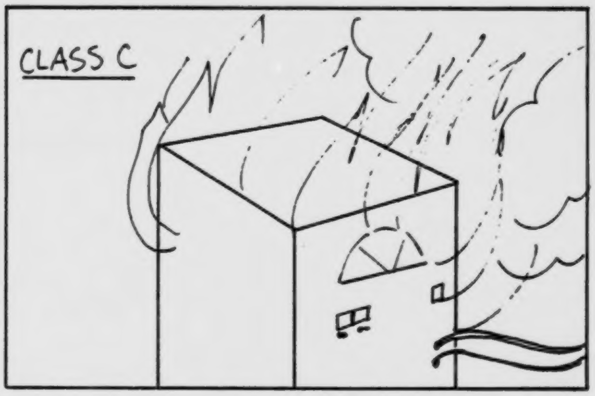


3. Class A fires occur when common solid combustibles such as paper, cloth or wood burn.

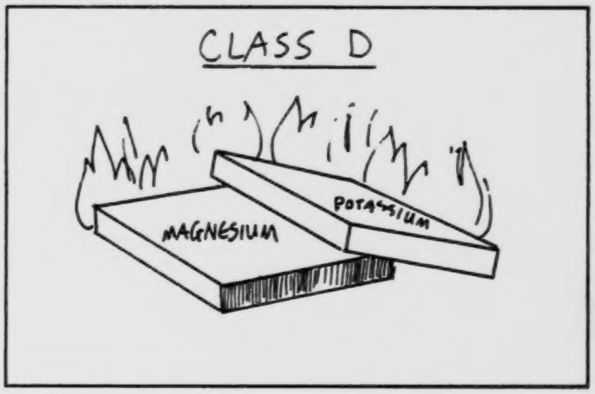
4. Class B fires occur when oil, grease, paint or other liquids burn.



5. Class C fires occur when electrical wiring and/or equipment burns. If a welding machine develops a short and burns, it is a class C fire.



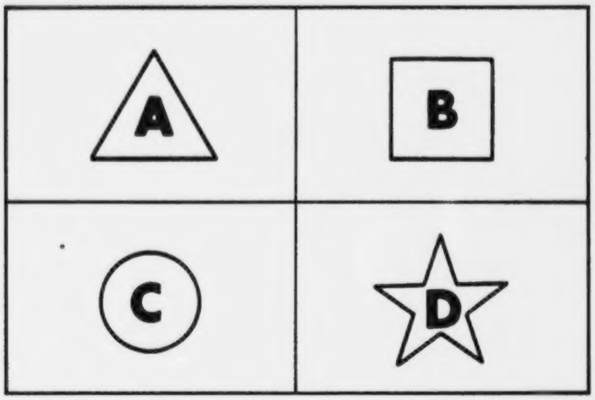
6. Class D fires occur when metals such as magnesium, potassium or powdered aluminum burn.



7. You cannot use the same fire extinguisher to put out all four types of fires. Different fire extinguishers are made for use on different classes of fires.

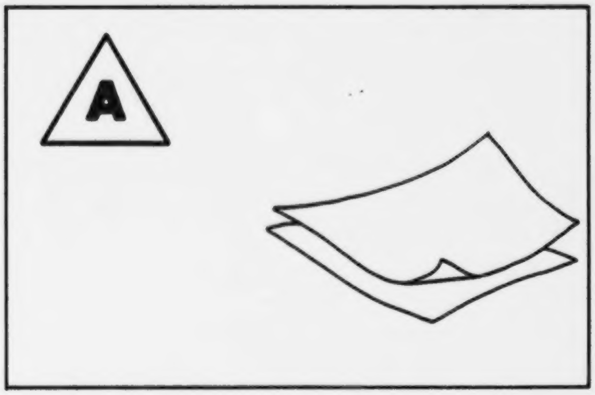
CAUTION:
You can make fires worse if you use the wrong type of fire extinguisher!

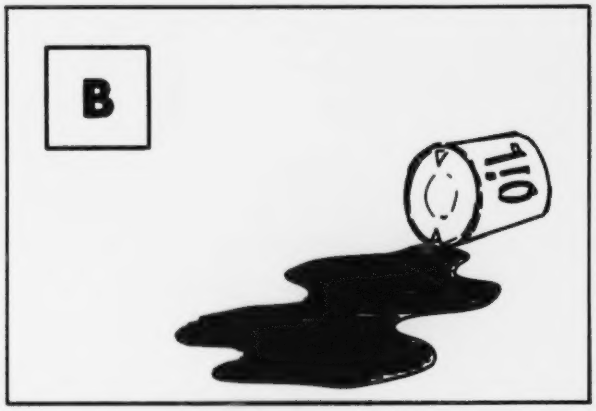
8. Fire extinguishers are marked according to the class(es) of fire they can put out.



9. Class A fire extinguishers should be used to put out burning common combustibles.

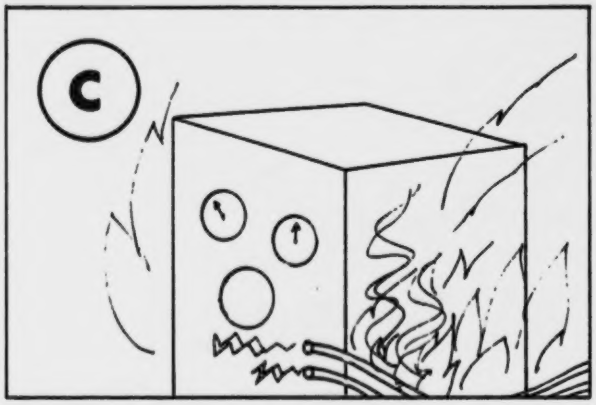
Class A fire extinguishers contain water and are labelled A.



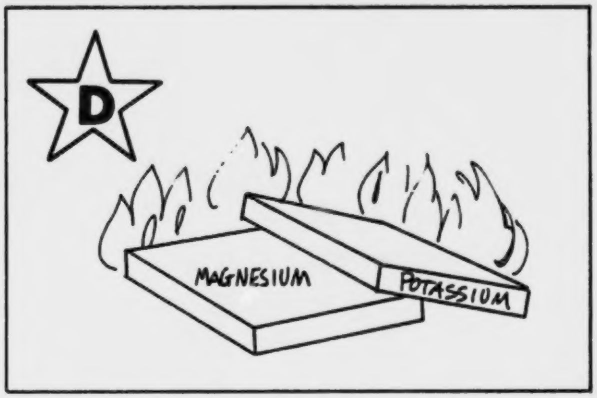


10. Class B fire extinguishers should be used to put out burning flammable liquids. Class B fire extinguishers contain either CO_2 or dry chemicals and are labelled B.

11. Class C fire extinguishers should be used on electrical fires. Class C fire extinguishers contain either CO_2 or dry chemicals and are labelled Ⓒ.

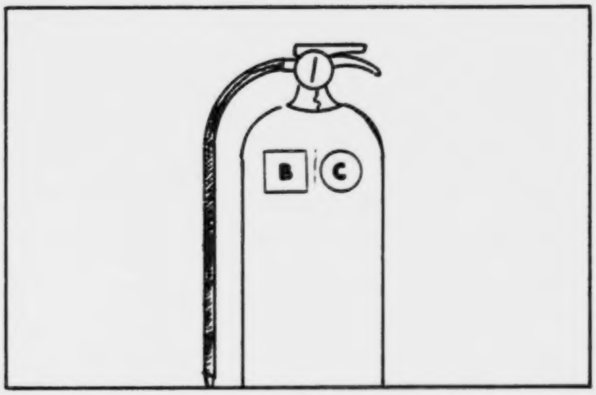


12. Class D fire extinguishers should be used on burning metal fires. Class D fire extinguishers are labelled ☆D.



Because different flammable metals require different extinguishers, you need to read the label to see what burning metals your class D fire extinguisher will put out.

NOTE: Many fire extinguishers can put out more than one class of fire. These fire extinguishers will be labelled with more than one symbol. For example, if a fire extinguisher had both a "B" and a "C" on it, you could use it on a class B or class C fire.



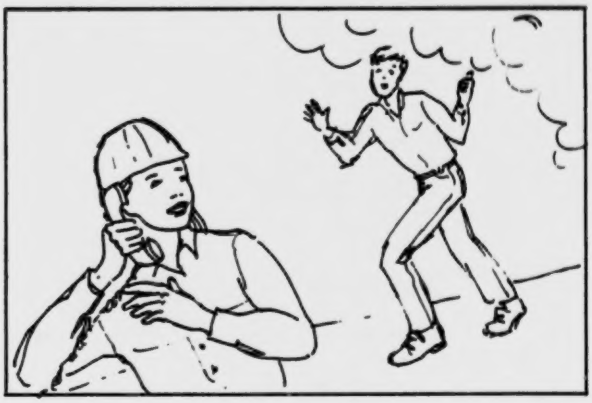
Do Activity Sheet 2.

ACTIVITY SHEET

Go to the welding shop. Locate all fire extinguishers in the shop. List each type (A, B, C, D, Multipurpose) of extinguisher and write the type of fire (paper, metal, eletrical, etc.) each extinguisher can be used to fight.

E. Fighting a Fire

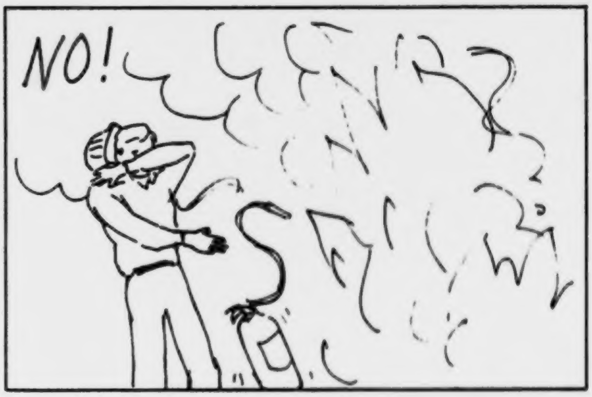
Different types of fire extinguishers work differently. Ask your instructor or supervisor to show you how to use each type of fire extinguisher in your shop. Then you will know how to use them in an emergency.



1. If a fire occurs, you should notify your supervisor and co-workers immediately.

2. Do not try to fight the fire if it will put you in danger.

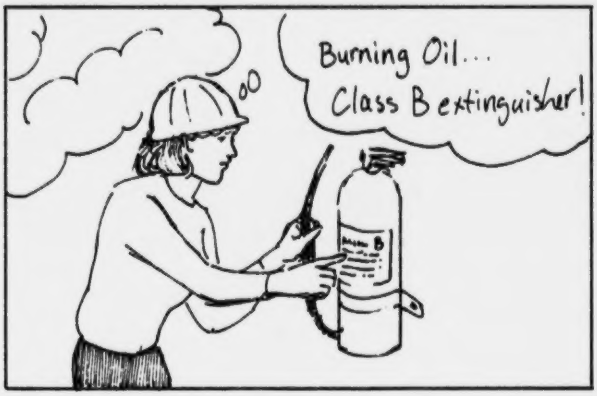
   CAUTION: If you cannot safely fight the fire, exit the building as quickly as possible by the recommended escape route.



3. If you must exit the building, stay calm and follow the escape route. Stay out of the building until it is safe to return.

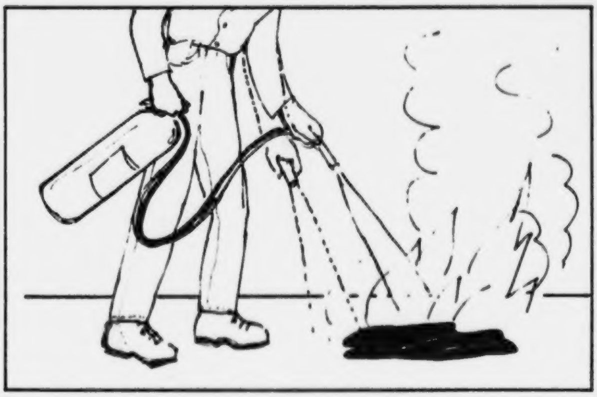
If you decide you can fight the fire safely, follow these steps:

4. To fight the fire with the least amount of danger to yourself, first determine what is burning so you can decide which class of fire it is.


Burning Oil...
Class B extinguisher!

5. Select the proper fire extinguisher for that class of fire (or use a multi-purpose fire extinguisher).

6. Use the fire extinguisher in the correct manner. Spray at the base of the flame and use a sweeping motion.

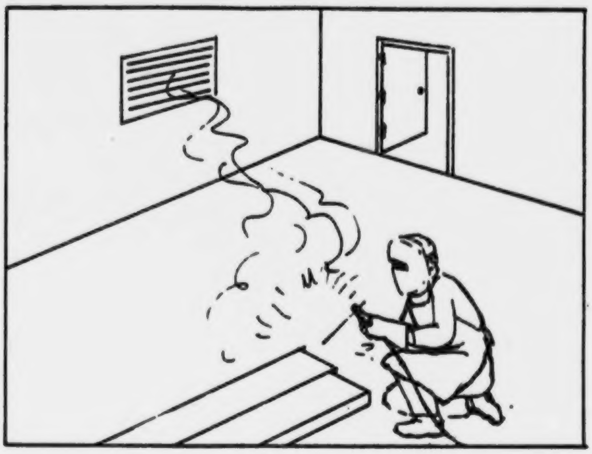


CAUTION: Be aware of smoke or dangerous gases that may be created by the fire.

7. Spray the fire until the flame is completely out. Check to make sure all flames are out.

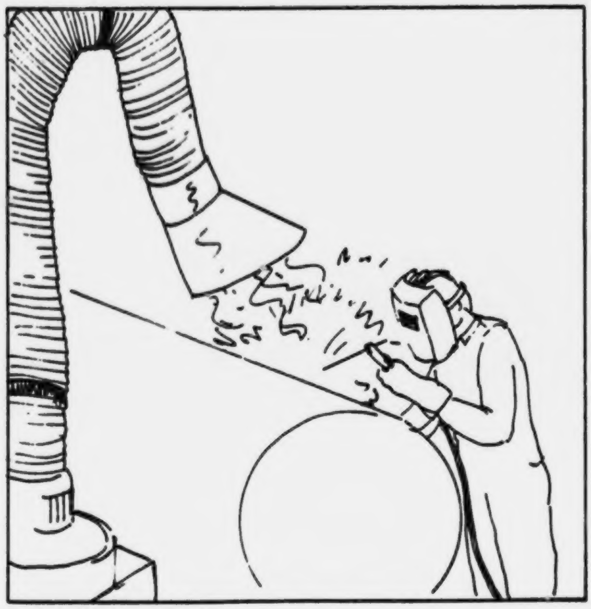
   NOTE: If someone's clothing catches on fire, use a wool blanket to smother the flames. Do not try to use a fire extinguisher.

F. Identifying Ventilation Hazards



1. Welding shops must have good ventilation. Good ventilation prevents smoke, fumes and gases from filling the shop and helps keep welders healthy.

2. To ensure good ventilation in your shop, turn on the exhaust fans to pull the smoke and fumes outside.



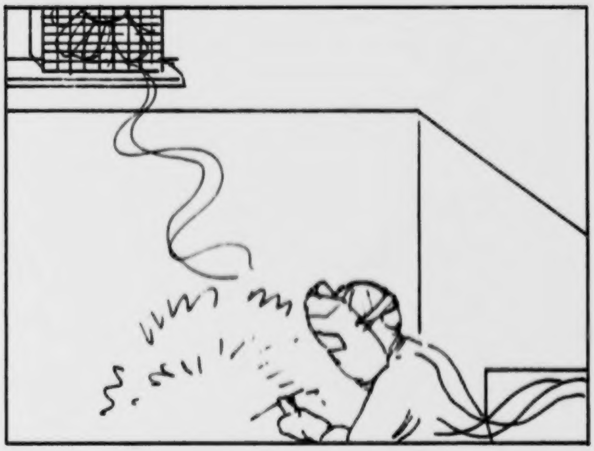
3. Open doors and windows to let fresh air in and smoke or fumes out.

   NOTE: Direct capture ventilation systems are becoming more common in welding shops.

   These systems capture smoke, fumes and gases at their origin and filter them before they can escape into the shop.

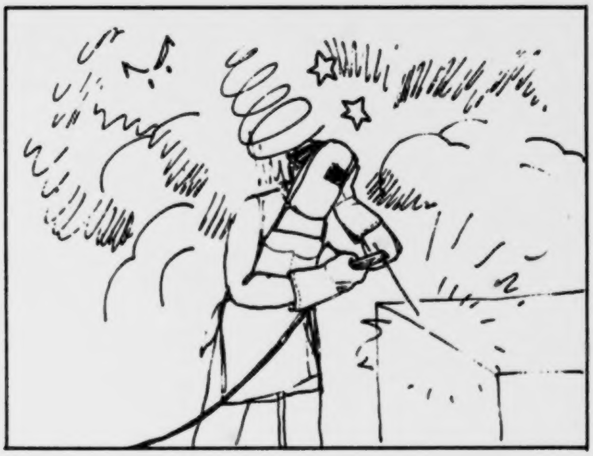
4. If you have to work in a confined area such as the inside of a box or tank, make sure the area is properly ventilated.

   There should be a fan at the top to pull out smoke and an opening at the bottom to let in fresh air. **NEVER VENTILATE WITH OXYGEN.**



5. Always look out for ventilation problems. If smoke accumulates, there may be a ventilation problem. If you cannot correct the problem, report it to your supervisor.

   CAUTION: Inhaling smoke or gas can make you very sick and can kill you. Always be aware of this danger and take steps to avoid it.



Do Skill Sheet 2.

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SKILL SHEET 2

1. List three things you can do to increase ventilation in the welding shop.

   1. ______________________________

   2. ______________________________

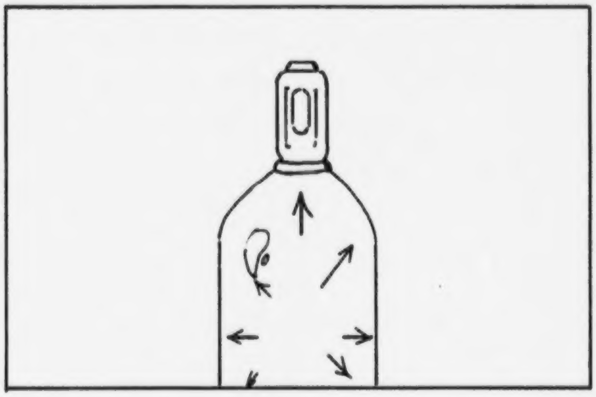
   3. ______________________________

2. True or false.

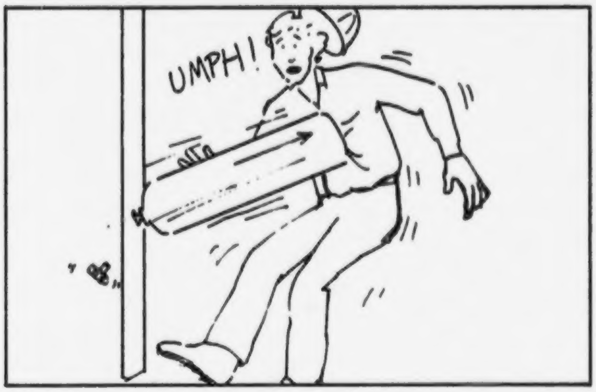
____ 1. Any type of fire extinguisher can be used on an electrical fire.
____ 2. Always point the fire extinguisher towards the base of the fire.
____ 3. The best time to learn where fire extinguishers are located is when a fire breaks out.
____ 4. Alert your supervisor and co-workers quickly when you find a fire.
____ 5. Always notify your supervisor after using a fire extinguisher.

G. Handling and Storing Welding Cylinders Safely

1. When cylinders are full, they are under extreme pressure. Because cylinders under pressure are dangerous, they must be handled and stored safely.

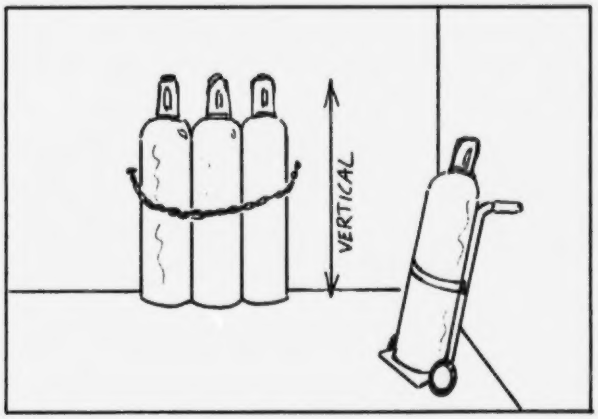


2. If cylinders are not safely handled and stored, they can cause serious accidents. If a valve is broken off of a full cylinder, the cylinder can take off like a rocket.

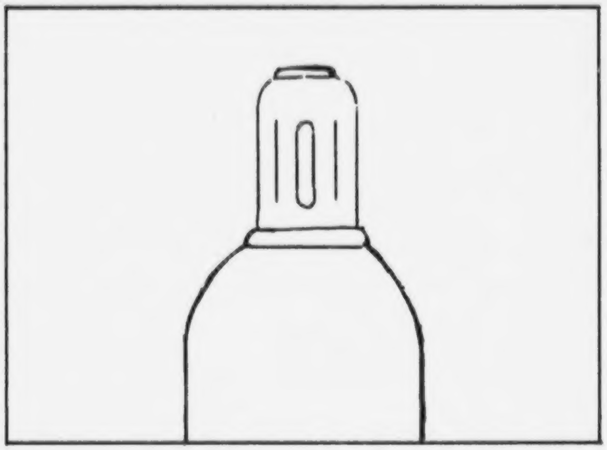


3. Cylinders in storage should always be strapped or chained to a wall, beam or rack so they cannot be knocked over.

4. Cylinders in use should be securely strapped or chained to a portable cart, wall, beam or rack.

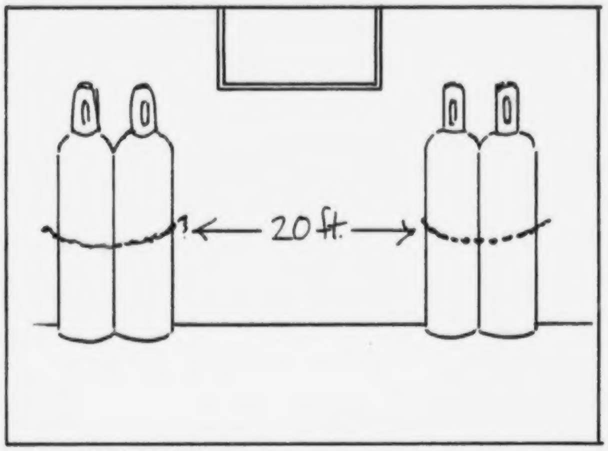


5. Cylinders in storage need their protective caps in place. The cap protects the valve.



6. All cylinders, whether empty or full, must stand upright at all times. **Never lay a cylinder on its side.**

7. Oxygen and acetylene cylinders should never be stored together in the same place. There should be at least 20 feet between oxygen and acetylene cylinders, unless an approved fire resistant wall separates them.



8. Cylinders should be stored in a properly ventilated area. Good air flow helps prevent a fire or explosion if a cylinder leaks.

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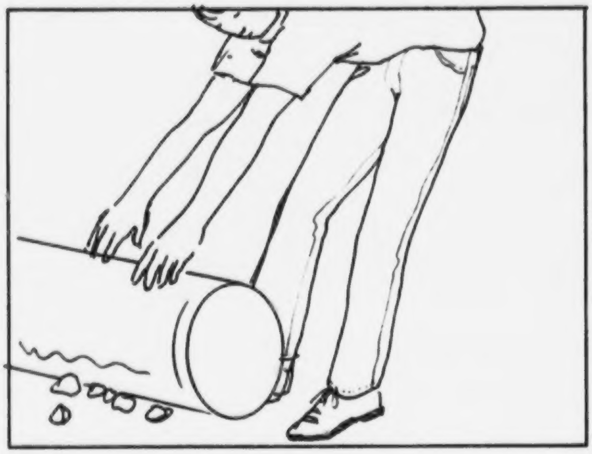
9. Never use a cylinder as a "roller." In other words, don't use a cylinder:

   - as a cart for moving another object,

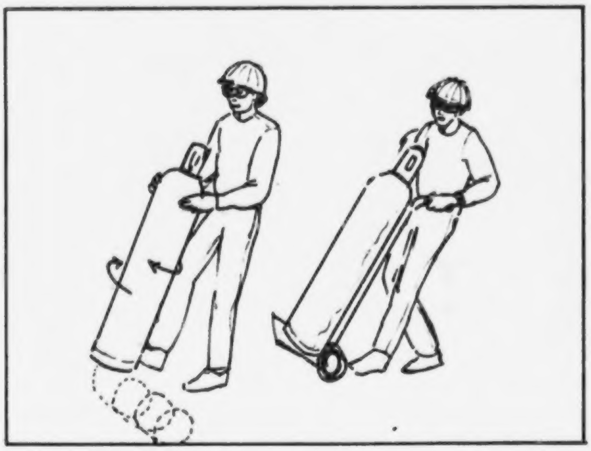
   - as a spool to wind rope, cable or wire on,

   - as a rolling pin to crush or smooth materials with.

   Such uses can cause cracks, leaks or other damage to the cylinder -- and damage causes accidents.



10. Always move cylinders properly and safely. Make sure the protective cap is in place before moving a cylinder.



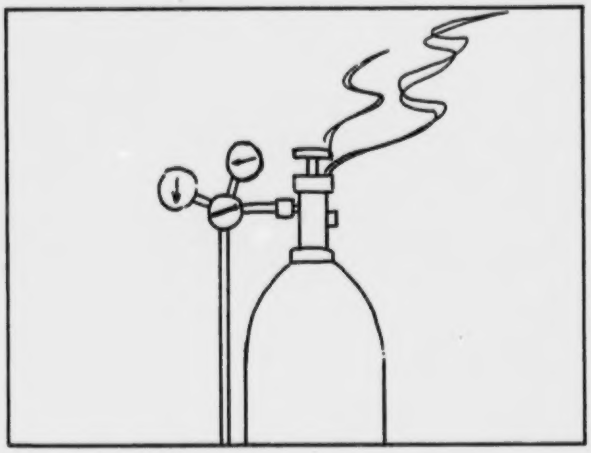
11. There are only two proper ways to move a cylinder.

    - You can chain it to a portable cart and move the cart.

    - You can roll the cylinder carefully on its bottom rim.

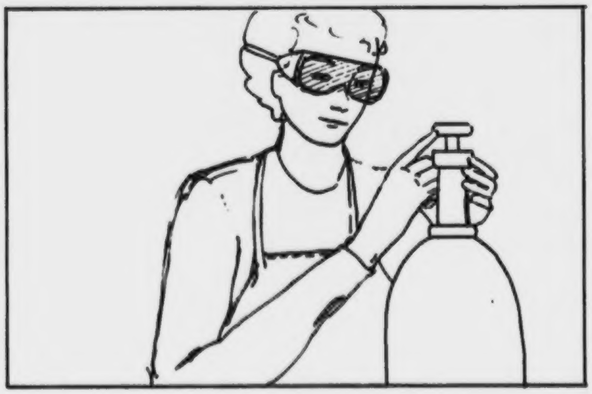
NOTE: Roll the cylinder in a clockwise motion. If you roll it counterclockwise, you may unscrew the protective cap.

12. **Never use a cylinder that has a leaking valve or a dent.**



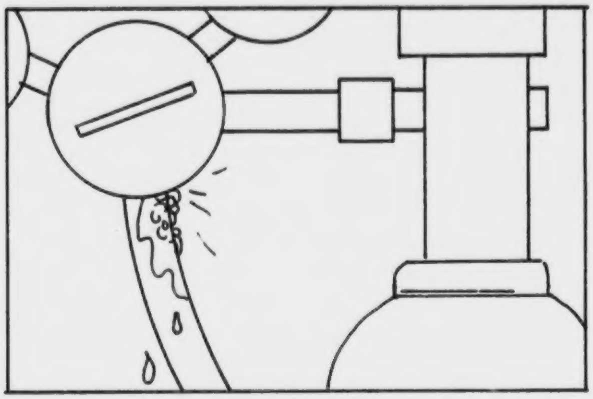
H. Using Oxyacetylene Welding Safety Procedures

1. Before beginning work each day, carefully study hoses, fittings, cylinders and regulators for damage or loose connections.



2. Always check for leaks after new connections are made. Regularly check all fittings, hoses and equipment.

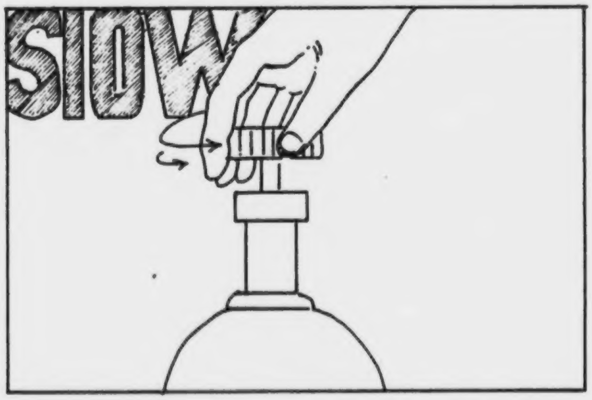
   NOTE: Use leak detector solution or soapy water to check for leaks in fittings and hoses.



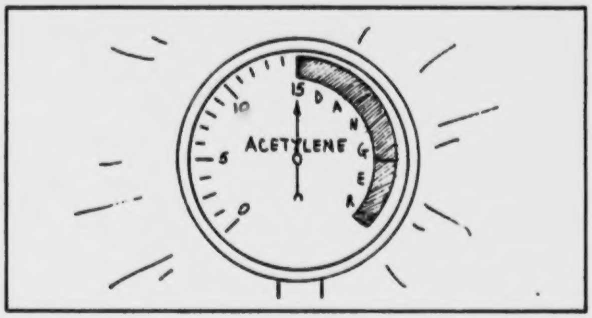
3. Release the adjusting screw on the regulator before you open a cylinder valve.

   CAUTION: Stand to the opposite side of the regulator when opening a cylinder valve.

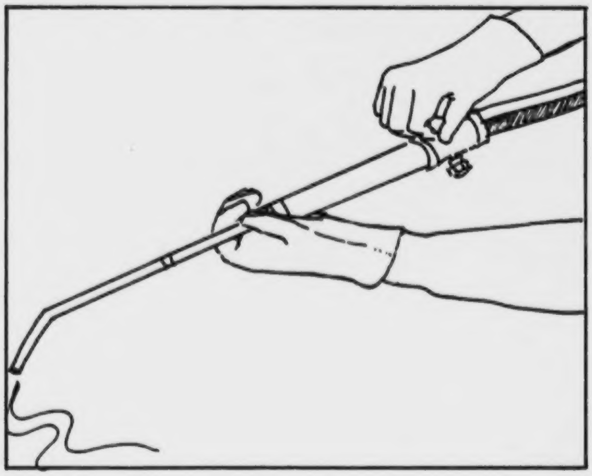
4. Open a cylinder valve SLOWLY. Open oxygen cylinder valves all the way. Open acetylene cylinder valves only three quarters to one and a half turns.



5. Do not use or compress acetylene at pressures higher than 15 PSI because an explosion may occur.

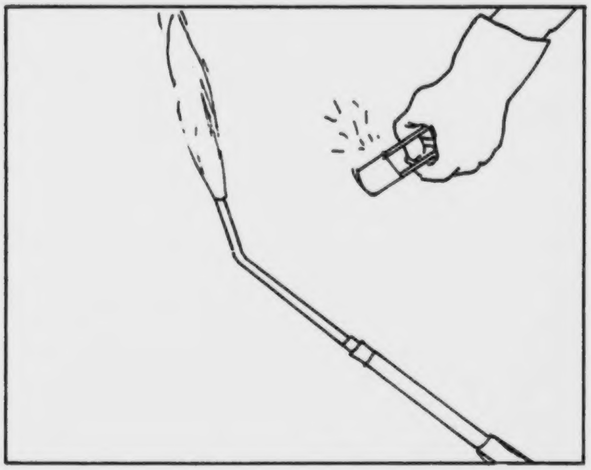


6. Purge the oxygen and fuel gas lines before lighting the torch.



7. Do not substitute oxygen for compressed air. Oxygen can start a fire or explosion.

8. To avoid fires, keep heat, flames and sparks away from items that might burn.

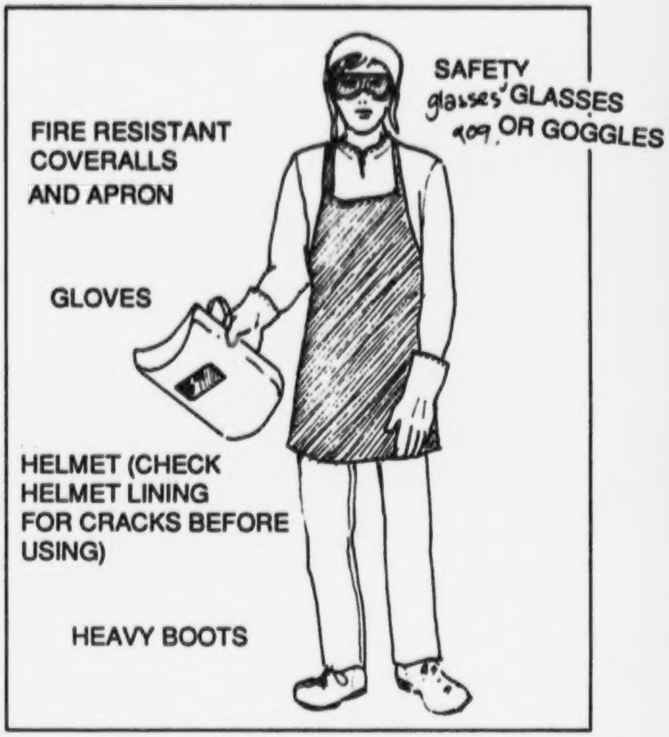


9. Light the acetylene before opening the oxygen valve on the torch.

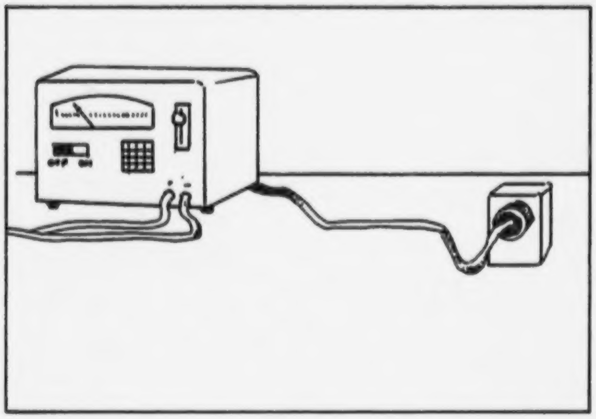
10. CAUTION: NEVER use oil on regulators, torches, fittings or other equipment that might come in contact with oxygen. When oil and oxygen come together, a fire or explosion may occur.

I. Using Arc Welding Safety Procedures

1. Always wear proper safety clothing and use proper equipment when arc welding.


SAFETY
glasses' GLASSES
gog. OR GOGGLES
FIRE RESISTANT COVERALLS AND APRON
GLOVES
HELMET (CHECK HELMET LINING FOR CRACKS BEFORE USING)
HEAVY BOOTS

2. Always turn the welding machine off when work is done or when you leave the area.

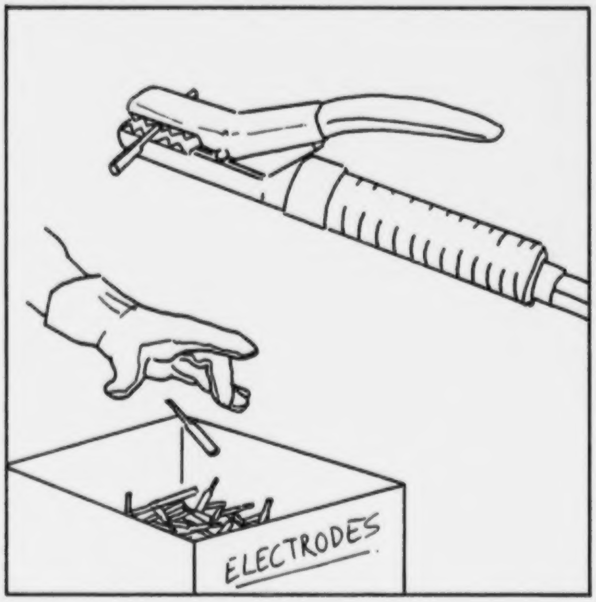


3. Make sure the welding machine is properly grounded.

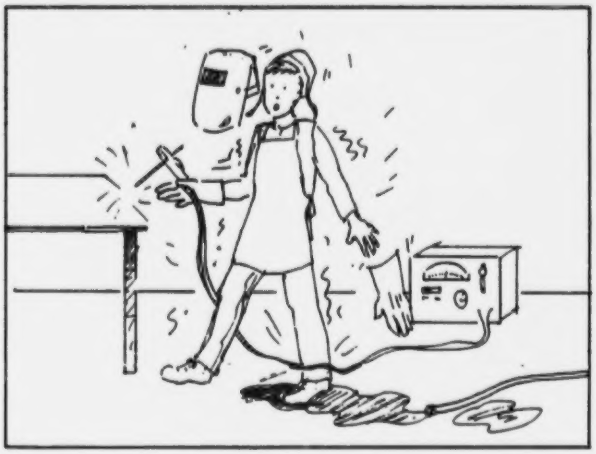
Note: Never touch an ungrounded machine because you may get an electric shock.

4. To prevent electrical shocks, burns, or other injuries, always remove the electrode from the holder after you finish welding.

5. Put electrode stubs in a proper container. Do not throw them on the floor or in the trash.

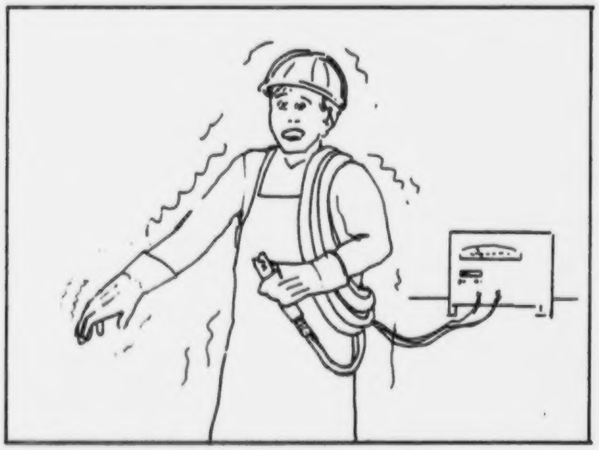


6. To avoid electrical shock, never weld in a damp or wet area.

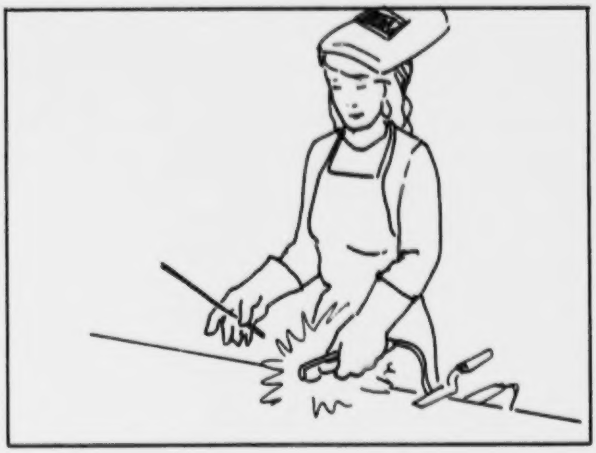


7. Keep welding cables dry and free of dirt and grease.

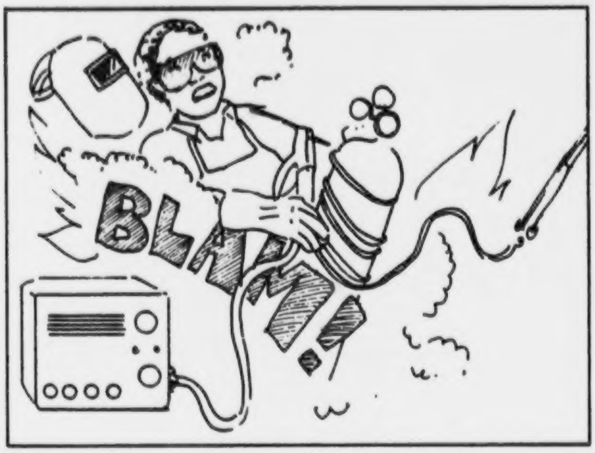
8. To prevent shocks, never put hooked-up welding cables around your shoulder or any part of your body.



9. Do not let the uninsulated part of the electrode holder touch grounded pieces. A flash, which may injure you, will result.

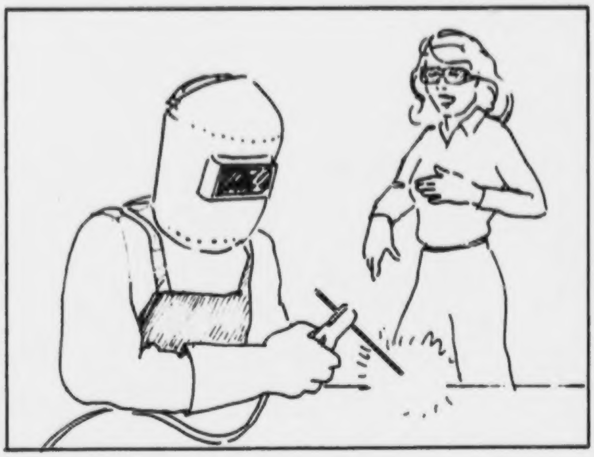


10. Never strike an arc or tap an electrode against a cylinder. The cylinder can explode.



11. Do not coil cables over cylinders. If the cables are damaged, an unplanned arc may occur, causing fire, explosions and/or injury.

12. Always warn others before striking an arc. Do not strike an arc if someone nearby is not wearing an arc welding helmet with the proper filter lens.



Do Skill Sheet 3.

SKILL SHEET 3

True or False.

____ 1. Always store cylinders in an upright and secured position.

____ 2. Cylinders can be stored without safety caps.

____ 3. To move a cylinder, hoist it onto your shoulder.

____ 4. Never use a cylinder as a roller to move a heavy object.

____ 5. Cylinders in use need not be chained.

____ 6. Never exceed 5 psi on an acetylene working pressure gauge.

____ 7. Never use oil or grease as a lubricant for oxyacetylene equipment.

____ 8. If a safety chain or strap is not available, weld the cylinder in place.

____ 9. Never arc weld in wet or damp areas.

____ 10. When finished with electrode stubs, throw them on the floor away from your work area.

UNIT REVIEW

True or False.

____ 1. Protective eyewear is required only when grinding.

____ 2. If you are not welding, you can take off your boots and wear tennis shoes.

____ 3. Leather gloves should fit snugly enough to keep from falling off your hands, but loosely enough to be thrown off in an emergency.

____ 4. You should clean your work area once a month.

____ 5. Never lift an object heavier than you can handle.

____ 6. Notify your supervisor if you notice an unsafe situation or safety hazard.

____ 7. You should test a fire extinguisher once a week to be sure it is in working order.

____ 8. Always know where the closest fire extinguisher is to the area you are working in.

____ 9. If smoke accumulates in your work area from welding, poor ventilation may be present.

____ 10. Always chain or strap cylinders that are being used, stored and transported.

____ 11. Cylinders too heavy to lift may be laid down and rolled to the desired location.

____ 12. A protective cylinder cap must be put on each cylinder that is not in use, whether the cylinder is full or empty.

____ 13. Never exceed 15 psi on an oxygen regulator.

____ 14. Never use oil on an oxygen cylinder.

____ 15. A torch may safely be lit by matches or a cigarette lighter.

____ 16. Always turn a machine off when it is not in use.

____ 17. Never weld near a puddle.

____ 18. Carry live electrode cables over your shoulder to eliminate wear on the cables.

____ 19. Welding or pounding on a cylinder is unsafe.

____ 20. When you finish welding, you should throw your used electrode stubs on the floor so that trained janitors can sweep them up.

PERFORMANCE CHECKLIST

Student ______________________________ successfully performed the following tasks:

	Yes	No	Comments
1. Wore proper clothing in the shop			
2. Followed shop safety procedures			
3. Used fire extinguishers properly			
4. Found and fixed ventilation hazards			
5. Handled gas cylinders correctly			
6. Stored gas cylinders correctly			
7. Used Oxy-fuel welding safety rules			
8. Used Oxy-fuel cutting safety rules			
9. Used Arc Welding safety rules			

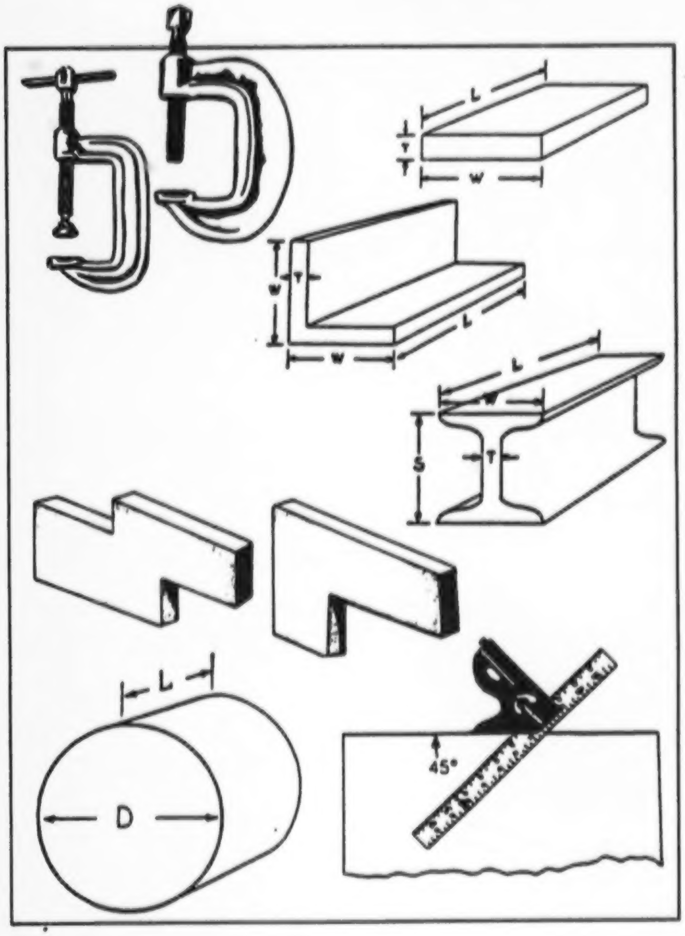
Satisfactory - should move on ☐

Should repeat this unit ☐

______________________________ Student's Signature/Date

______________________________ Instructor's Signature/Date

WELDING Supplementary Units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Using Machinery Safely

USING MACHINERY SAFELY

INTRODUCTION

Welders must be able to use machinery safely, not only to protect themselves, but to protect their co-workers. A welder should work safely at all times, especially when working with power equipment. Safety should be the welder's first consideration.

UNIT OBJECTIVES

After completing this unit, you will be able to safely work with tools and machines commonly found in a welding shop.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to specifically:

1. Safely use the drill press.
2. Safely use power saws.
3. Safely use the pedestal, bench and disc grinder.
4. Safely use shears, brakes and rollers.

ARE YOU READY?

CHECK THE STATEMENT THAT IS TRUE FOR YOU:

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms and Equipment

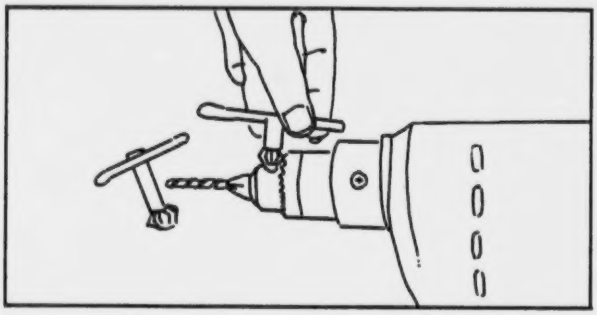
1. **Bit** - a cutting tool used in a drill or drill press.
2. **Brake** - a machine that bends sheet metal.
3. **Chuck** - the front part of the drill or drill press that holds the bit in place while drilling.
4. **Center punch** - a tool resembling a chisel that makes a small indentation to help the drill bit stay in place.
5. **Chuck wrench** - a tool used to tighten the jaws of the chuck around a bit so it doesn't come loose when drilling.
6. **Drill** - a tool for making holes in metals.
7. **Drill press** - a large power tool for making holes in metals.
8. **Redress** - to recondition a grinding wheel.
9. **Roller** - a machine that curves or rolls metal.
10. **Shear** - a machine that makes straight, even cuts in sheet metal.
11. **RPM** - the standard abbreviation for "revolutions per minute." It measures the number of times an object revolves in one minute.
12. **Tool rest** - the part of the grinder that supports the object being ground.
13. **Trigger** - the switch that turns the drill on.

B. Safe Operation of Drills and Drill Presses

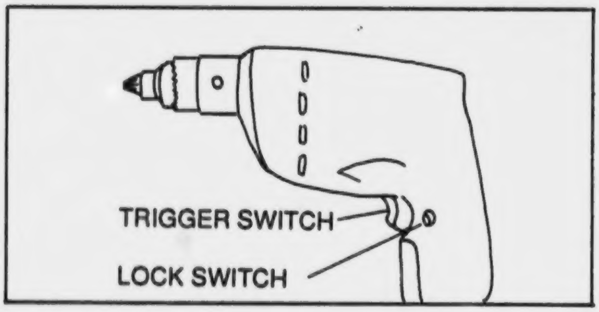
CAUTION: Never operate a machine until you know how to use it properly. Know how to shut the machine off before you turn it on.

Portable Electric Drills

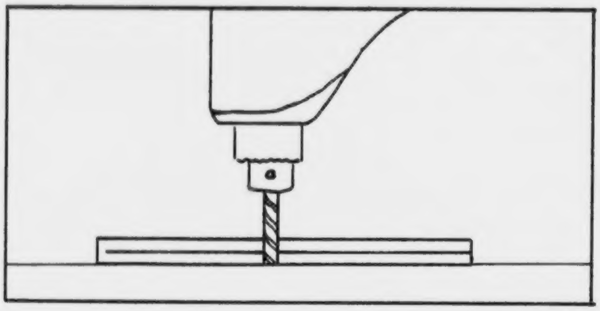
1. Tighten the bit securely in the chuck. Remove the chuck wrench after tightening the bit.



2. Never lock the trigger in the "ON" position.

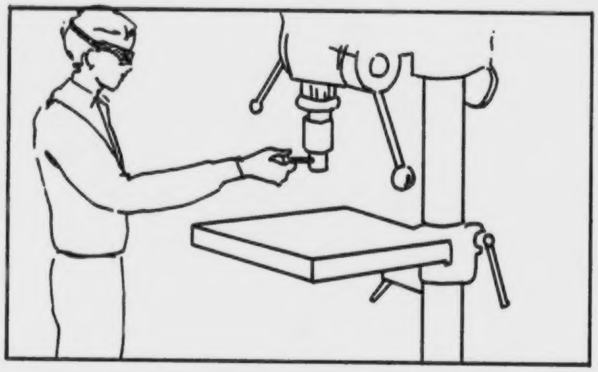


3. Reduce pressure on the drill just before the bit cuts through the metal. In other words, don't keep pushing hard on the drill as you finish the hole. If you keep pushing hard, the metal may rotate around the bit.

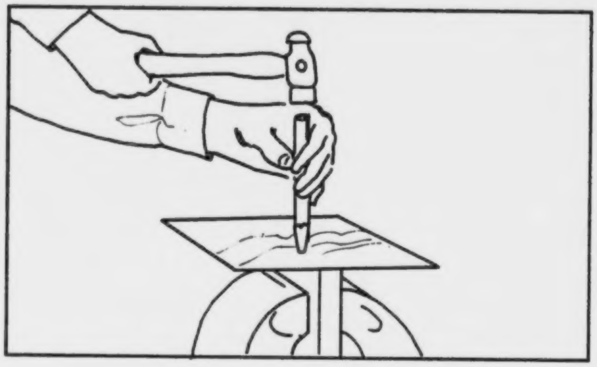


4. Never use your hands to stop metal that is revolving around the bit. Let go of the trigger switch and the metal will stop spinning.

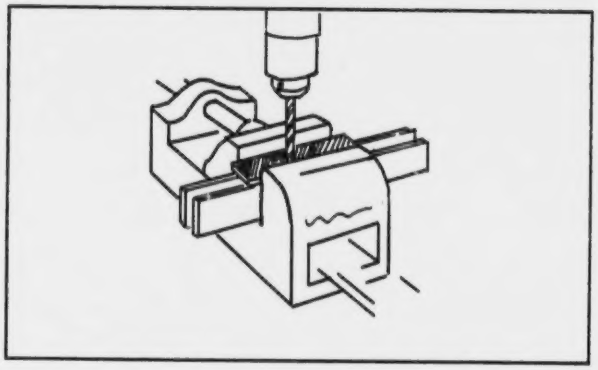
5. Tighten the chuck securely around the bit. When you tighten, use the chuck wrench in all three holes of the chuck. Always remove the chuck wrench after tightening.



6. Center punch the metal before drilling it. The center punch mark keeps the bit from wandering.

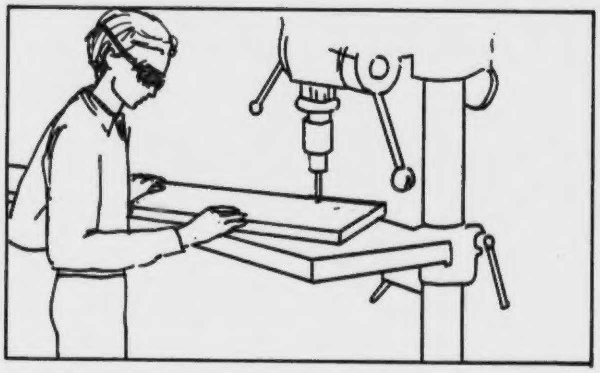


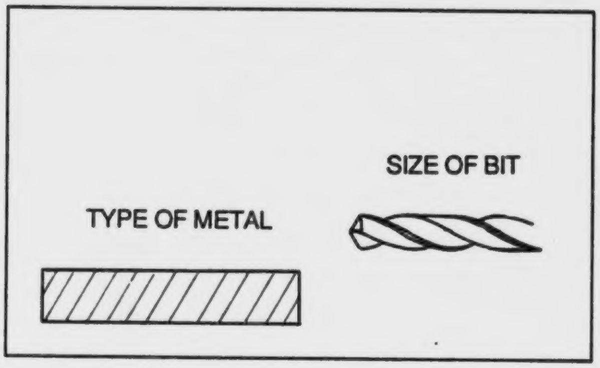
7. Use a vise or clamp to anchor the metal to the table of the drill press. Do not drill metal that is not securely fastened to the drill press table.



8. When drilling long pieces of metal, put the long end to your left.

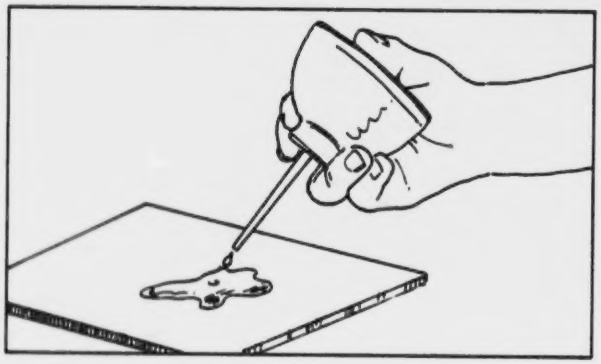
   If the metal turns with the bit and the long end is on your left, the metal will hit the post of the drill press instead of hitting you.



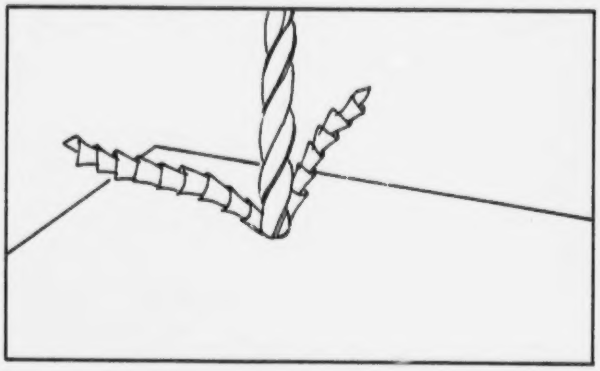


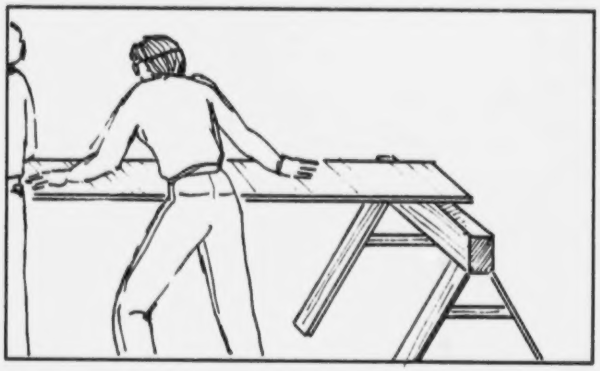
9. Select the proper bit speed (rpm's) for the type of metal and size of bit used. This information is usually given in a chart on the front of the drill press.

10. Do not try to force the bit through the metal. Use the recommended lubricant for the type of metal being drilled.



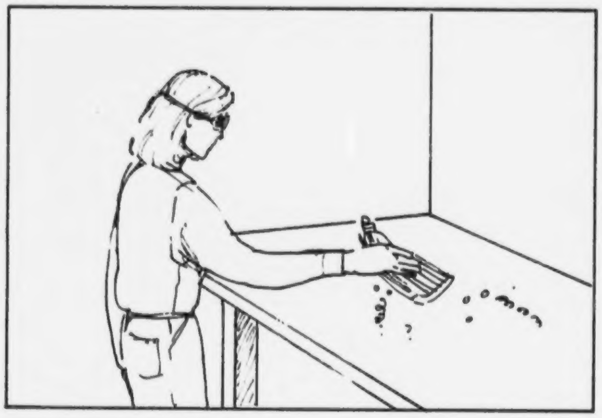
11. Do not allow long spirals of metal shavings to build up at the bit. When a spiral gets too long, reduce the pressure on the drill and the spiral will break.





12. Support the ends of long pieces of metal being drilled.

13. Reduce pressure on the drill just before the bit cuts through the metal. Not pushing as hard prevents the metal from revolving around the bit.



14. After the drill has stopped, you should clean the work area. Use a brush to clean up the metal shavings.

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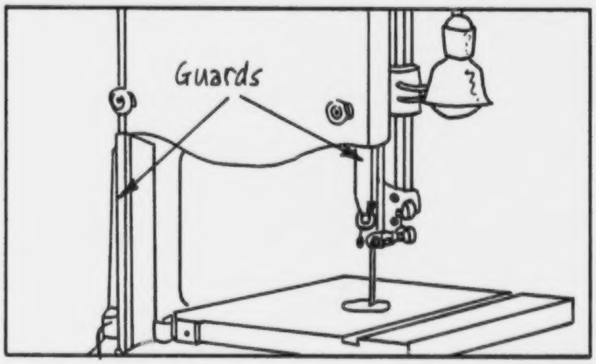
C. Safe Operation of Power Saws

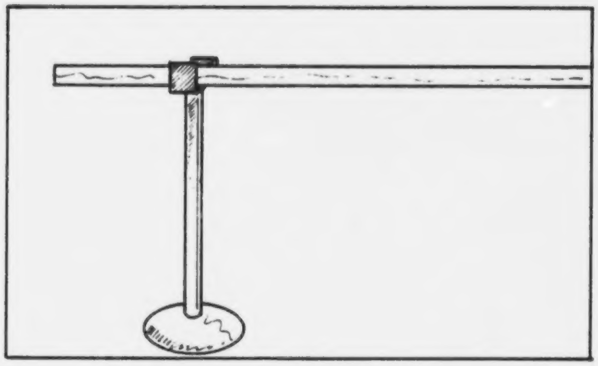
Many types of saws are common in a welding shop. The following safety rules apply to all common power saws.

1. Make sure all safety guards are in place and working correctly.

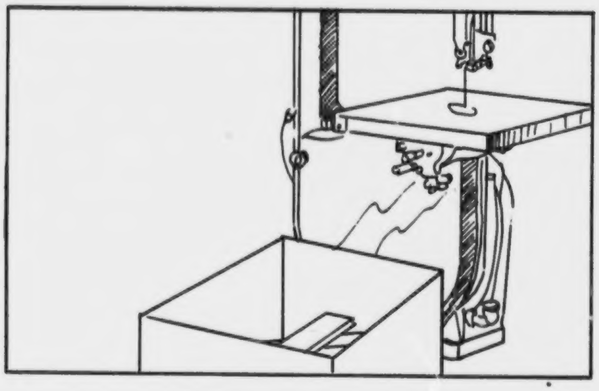


2. Adjust the blade guard as close to the blade as you can without interfering with saw operation.

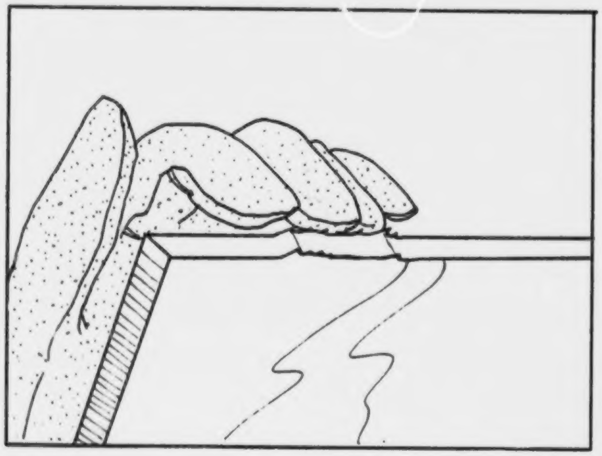
3. Support long pieces of material when sawing.



4. Make sure material cut off will fall in a safe place.

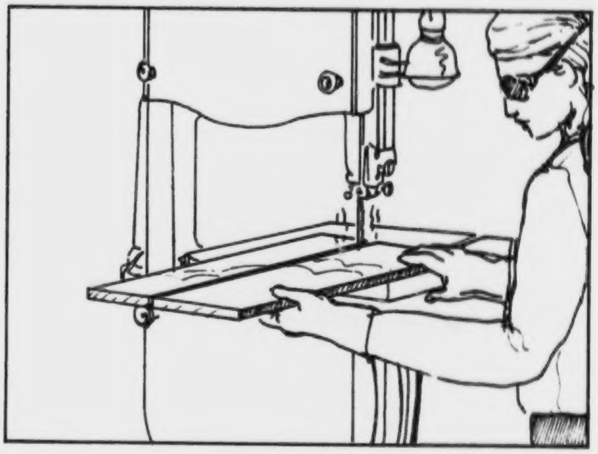


5. Be careful when handling pieces of metal that have been cut. They often have sharp edges and burrs that can cause painful cuts. Wearing gloves when handling metal can prevent many cuts.



6. Never force a saw to cut faster than it is supposed to. Forcing a saw is unsafe and will damage the machine. Use lubricant on the blade when required.

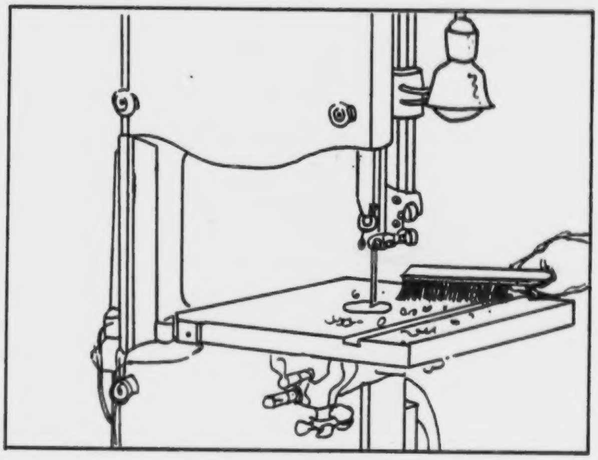
7. Wait until the blade has stopped before removing pieces from the saw.



8. Always keep the work area clean, neat and free of trash.

9. Use a brush to clean around the saw to protect your hands from metal shavings.

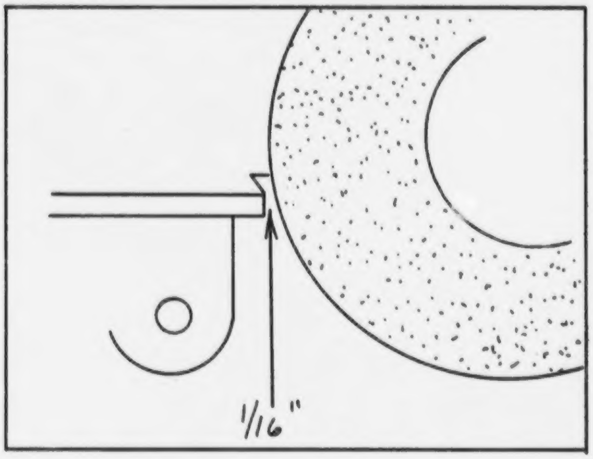
CAUTION: Never use your hand to wipe off a table or stand. Use a broom or brush.



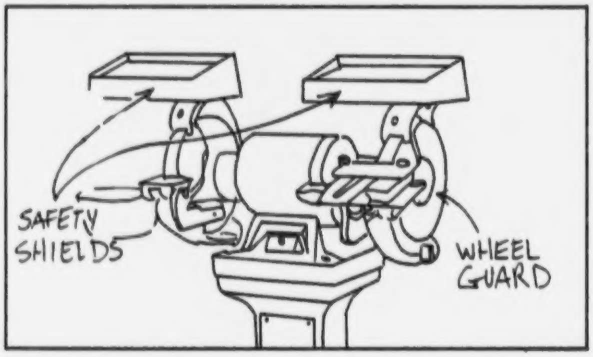
D. Safe Operation of Grinders

Pedestal and Bench Grinders

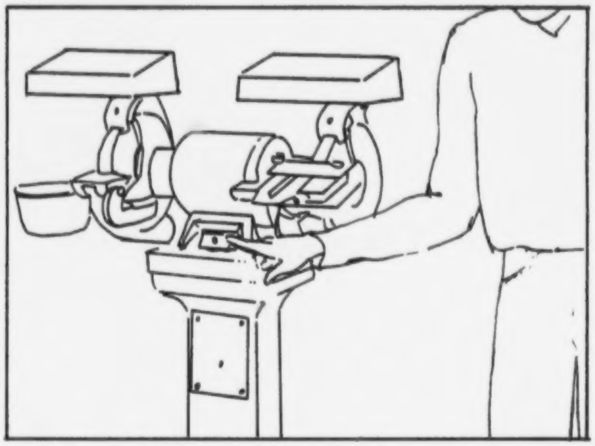
1. Always check the tool rest before using a grinder. The tool rest should be 1/16 of an inch or less away from the grinding wheel. The tool rest should be fastened tightly to prevent it from moving while you are grinding.



2. Make sure all safety guards are in the correct position and are working properly before you start the grinder.

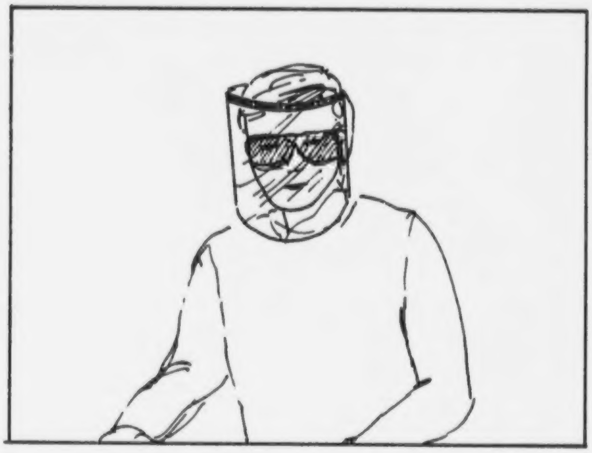


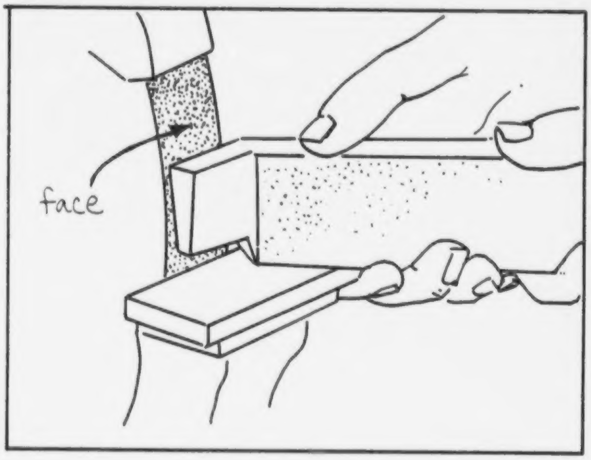
3. Stand to the side (not the front) of the grinding wheel when you start the machine. Grinding wheels have been known to fly apart when the wheel starts rotating.



4. Always wear goggles and a face shield when using a grinder. Wear a dust mask if ventilation is poor.

   NOTE: Gloves should never be worn when grinding. If a glove gets caught in a grinding wheel, the whole hand or arm may be pulled in.

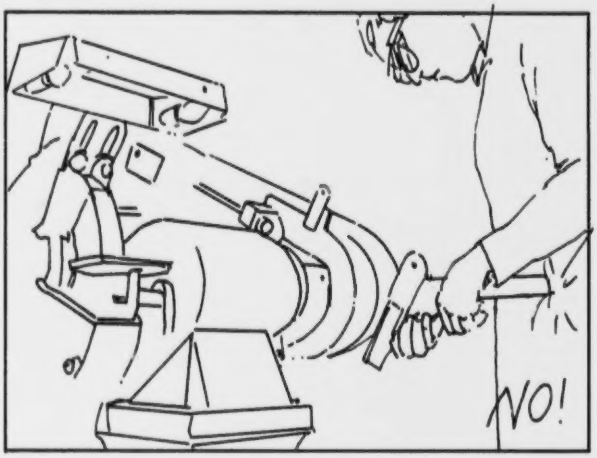




5. Only grind on the face of the wheel. Grinding on the side of the wheel may damage it.

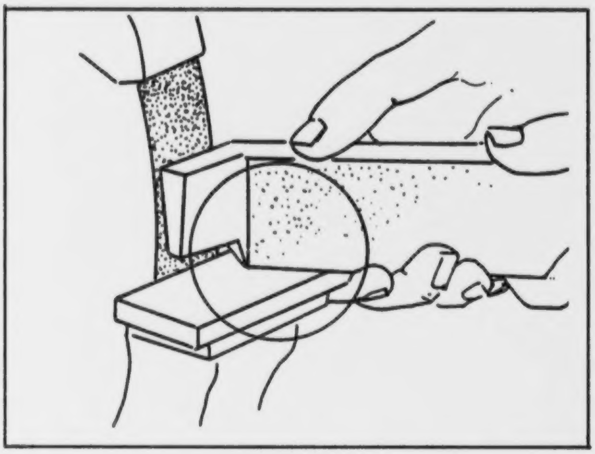
6. Do not run the grinding wheel at higher speeds than the manufacturer suggests.

7. Do not rest the end of what is being ground against your body. If the wheel kicks the object back, you could be seriously injured.



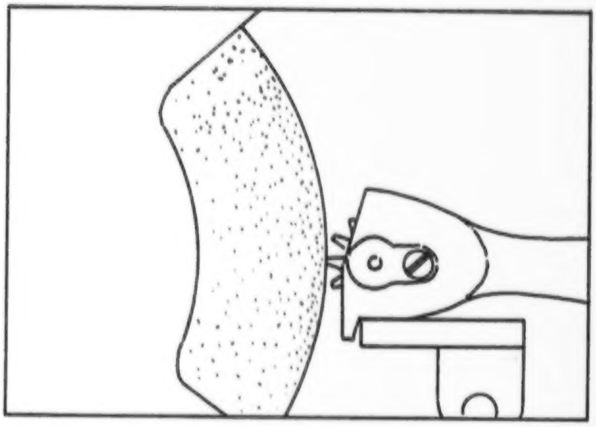
8. Position metal on the tool rest so it will not be jerked away from you or become wedged between the tool rest and grinding wheel.

   Small pieces of metal can be held with locking pliers (Vise-Grips) to prevent injury and/or losing control of the metal.

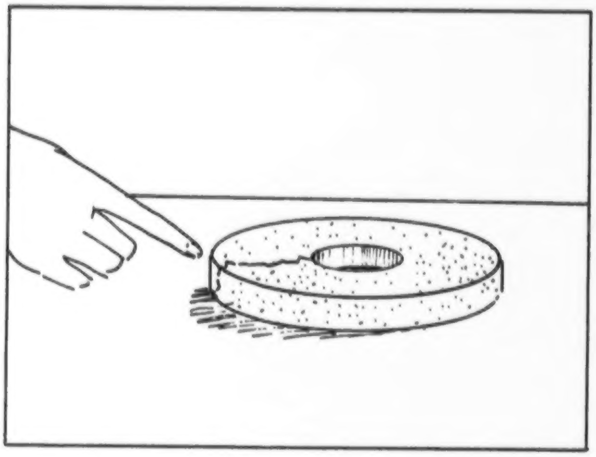


9. Never use excessive force to feed material into a grinder. You could damage the grinder. You could also slip and injure yourself.

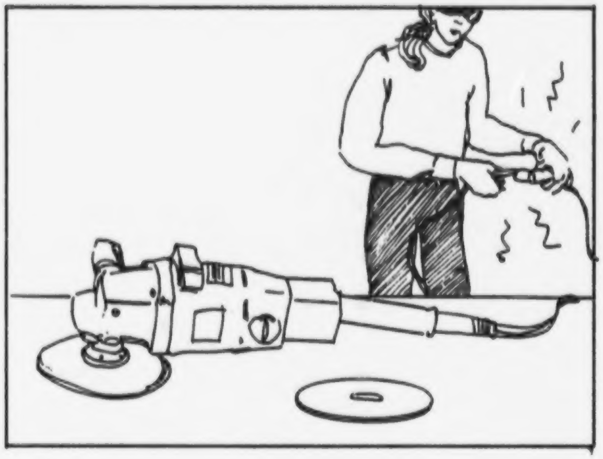
10. Redress or replace grinding wheels when necessary.



11. Always check to make sure grinding stones are not damaged before you mount them on the grinder. Discard damaged grinding wheels.



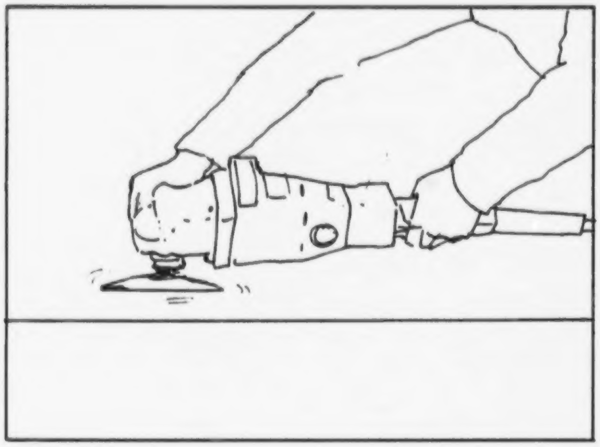
Disc Grinders



12. Always unplug the grinder before installing a new grinder disc.

13. Check to make sure that grinding discs are not damaged before you mount them. Discard damaged grinding discs.

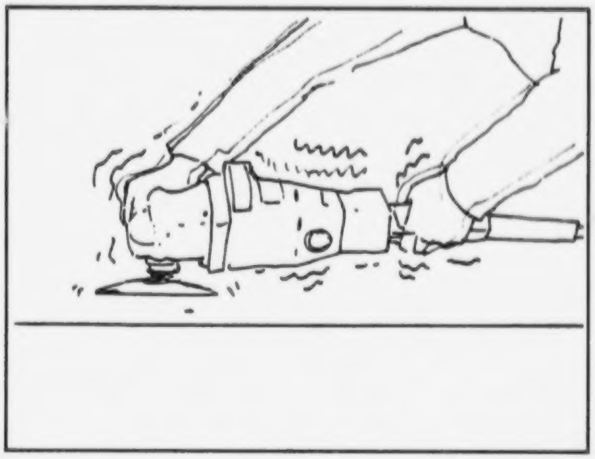
14. Once a new grinding disc has been mounted, do this test:



    - Hold the grinder two inches above the floor with the disc parallel to the floor.

    - Depress the switch. Allow the grinder to reach top speed and keep it there for 5 or 6 seconds.

- Release pressure on the switch and allow the disc to come to a complete stop.



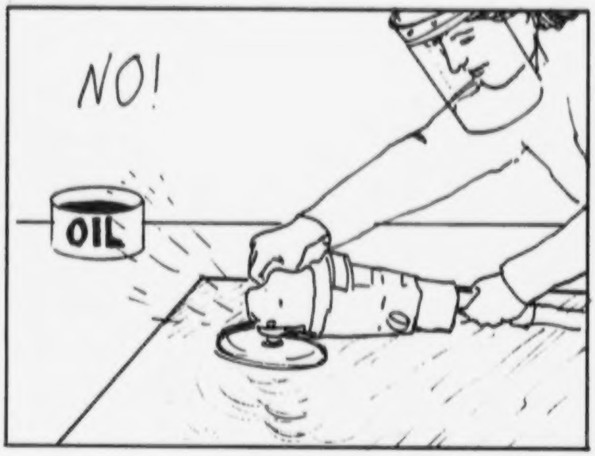
- If you hear or feel unusual noises or vibrations during this test, something is wrong. You must correct this condition before using the disc grinder.

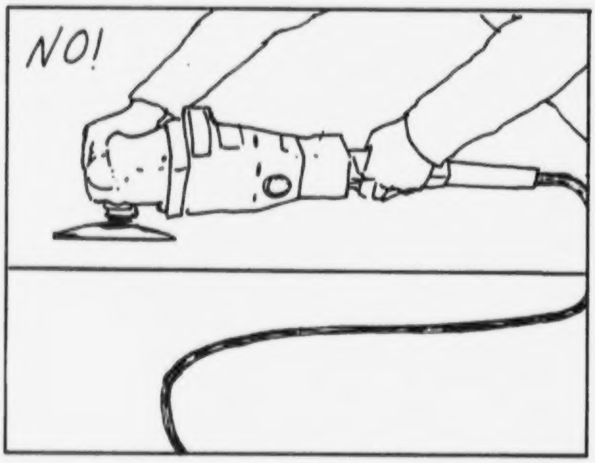
  (Only test the disc grinder in a safe area so no one will be injured if the disc breaks.)

CAUTION: Always use the disc guard. This guard directs sparks and particles away from you.

15. Always pay attention to the direction sparks and particles are being thrown. Do not direct them toward co-workers or flammable materials.

    NOTE: Whenever possible, you should use a portable screen to block the sparks and particles.

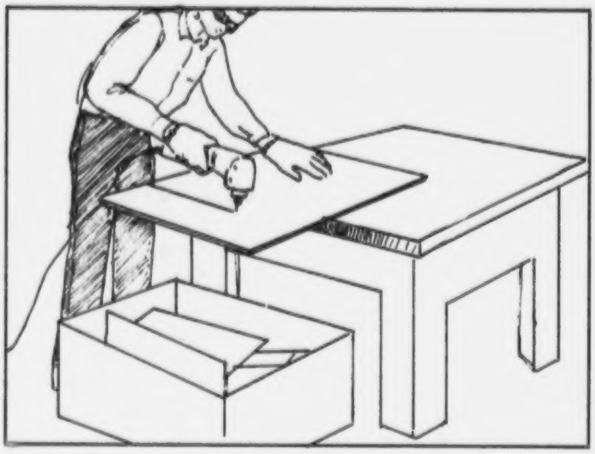




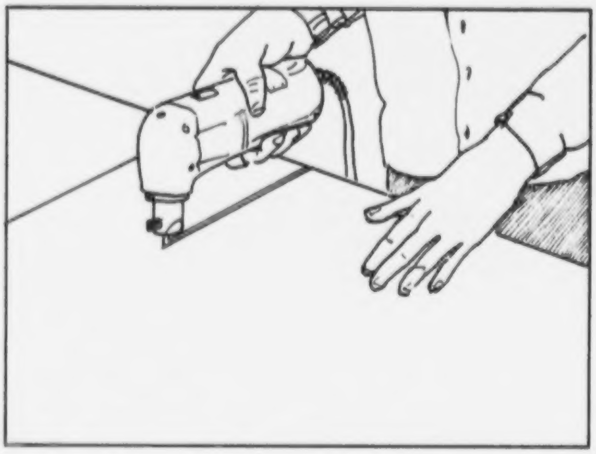
16. Keep the power cord away from the grinding disc. Keeping it away will prevent you from accidentally damaging it.

17. Always keep a firm grip on the grinder. Use both hands to hold it.

E. Safe Operation of Shears, Brakes, and Rollers



1. Make sure metal is in correct position before turning the machine on.
2. Always stand to the side when operating the machine.
3. Plan ahead -- see where the cut or moving pieces will go.



4. Make sure your body and clothing are in a safe position before operating the machine. Also, check to see that co-workers are safe before you operate the machine.

UNIT REVIEW

1. Three general safety rules are listed below. Write a short statement explaining why each rule is important.

   a. Always shut power tools off when they are not in use.

   ____

   ____

   ____

   b. Always keep the work area clean and free from trash, chips and clutter.__________________________

   ____

   ____

   ____

   c. Never operate a machine until you know how to use it properly.______________________________

   ____

   ____

   ____

2. Fill in the blank with the word or words that best complete each statement.

Portable Electric Drills

A. The bit should be tightened securely in the ______________ of the drill.

B. You should not _________________ the trigger in the "on" position when using the drill.

C. You should _______ metal before you drill it.

D. You should ______________ pressure on the drill just before the bit cuts through the metal.

E. The metal you drill should always be securely ________________ to the table of the drill press.

Saws

F. You should wait until the ____________ has stopped turning before removing material from the saw.

G. Adjust the blade guard as _______________ to the blade as you can without interfering with saw operation.

H. Always keep the work area _______ and safe.

Pedestal and Bench Grinders

I. The tool rest should be ____________ inch or closer to the grinding stone.

J. You should stand to the _____________ of the grinding wheel when starting the grinder.

K. You should ________ damaged grinding wheels.

Disc Grinders

L. You should __________________ the grinder before installing a new grinding disc.

M. The _____________ guard directs sparks and particles away from you.

N. You should direct sparks and particles _____________________ co-workers or flammable materials.

O. Do not put the disc grinder down until the disc has ____________ turning.

Shears, Brakes and Rollers

P. You should stand to the ________________ when you operate these machines.

Q. Always make sure your body and ___________ are in a safe position before operating these machines.

PERFORMANCE CHECKLIST

Student ______________________________ successfully performed the following tasks:

		Yes	No	Comments
	Used the following machines safely:			
1.	Drill Press			
2.	Drill Motor			
3.	Band Saw			
4.	Pedestal Grinder			
5.	Hand Grinder			
6.	Shear			
7.	Rollers			
8.	Brake			

☐ Satisfactory - should move on

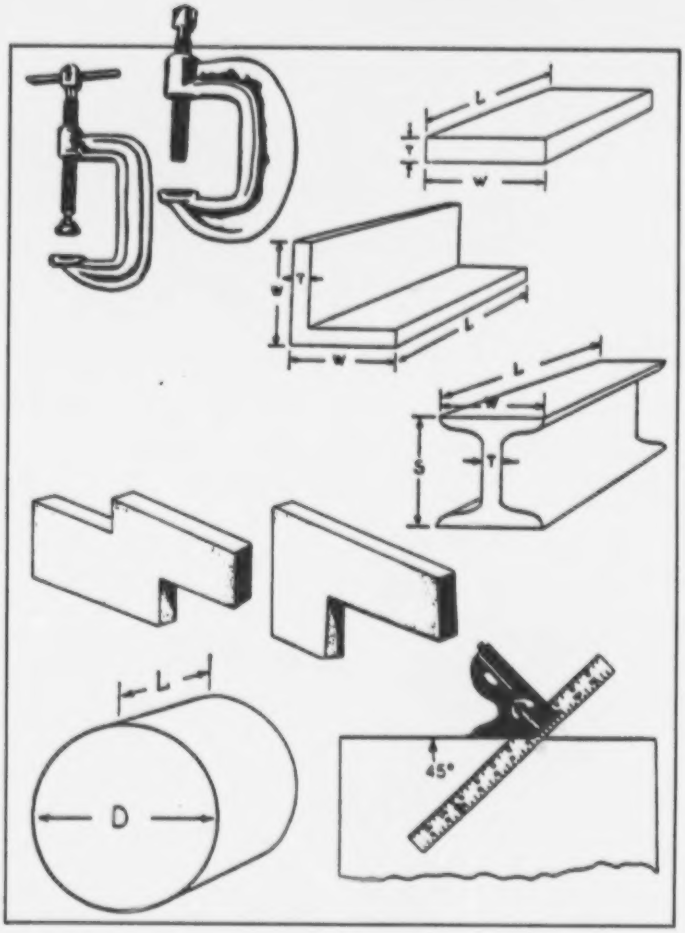
☐ Should repeat this unit

________________________ Student's Signature/Date

________________________ Instructor's Signature/Date

WELDING Supplementary Units

Metallurgy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METALLURGY

INTRODUCTION

Welders must know a great deal about metals. The welder must be able to identify each type of metal and name its properties. Because different metals react differently to heating, bending, cutting and welding, welders need to know the characteristics of different metals to work successfully with each.

UNIT OBJECTIVES

After completing this unit, you should be able to explain how metals react to heat. You should also be able to identify different types of ferrous metals and give examples to show how each type is used.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to specifically:

1. Recognize characteristics of metals.
2. Tell how metals react to heat.
3. Tell how to minimize distortion when welding.
4. Recognize how and why the spark test is used.

ARE YOU READY?

CHECK THE STATEMENT THAT IS TRUE FOR YOU:

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms and Equipment

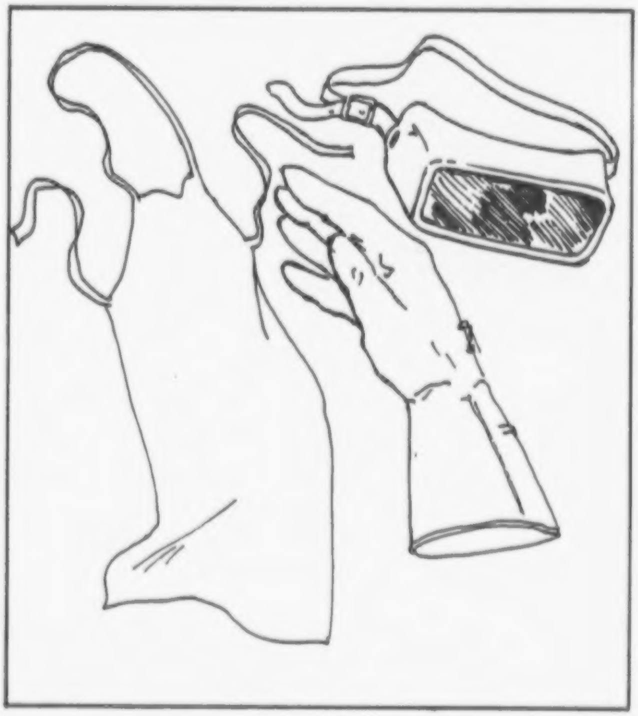
Terms

1. **Contraction** - the process of becoming smaller in size.
2. **Distortion** - the bending or twisting of an object from its original form.
3. **Expansion** - the process of becoming larger in size.
4. **Ferrous metals** - metals that contain iron. Ferrous metals are magnetic.
5. **Nonferrous metals** - metals that do not contain iron. Nonferrous metals are not magnetic.

Equipment

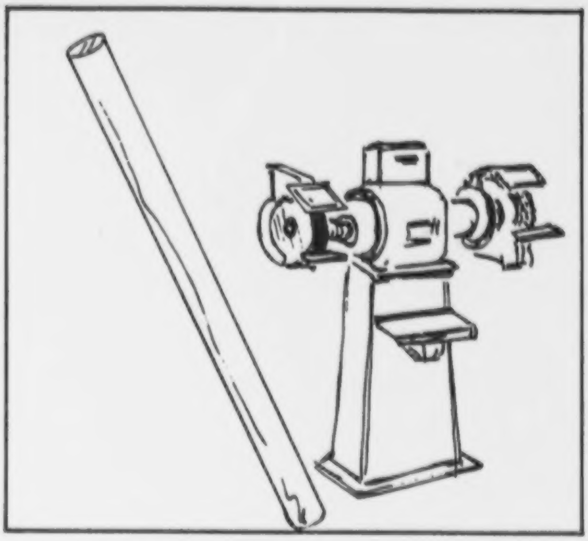
Oxyacetylene welding outfit

Safety equipment



Pedestal grinder

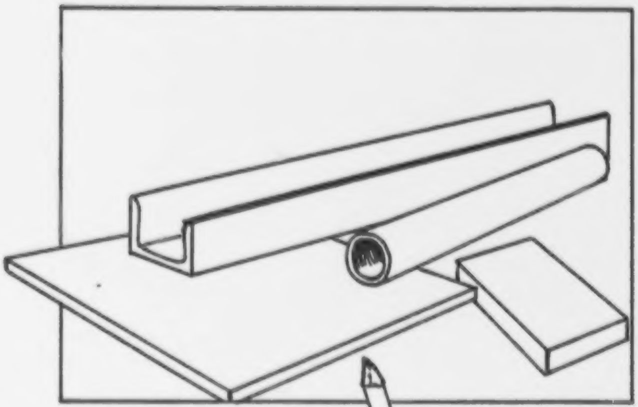
High carbon steel rod



Various types of ferrous metals:

1. **Wrought iron** - used in ornamental iron, rivets, etc.

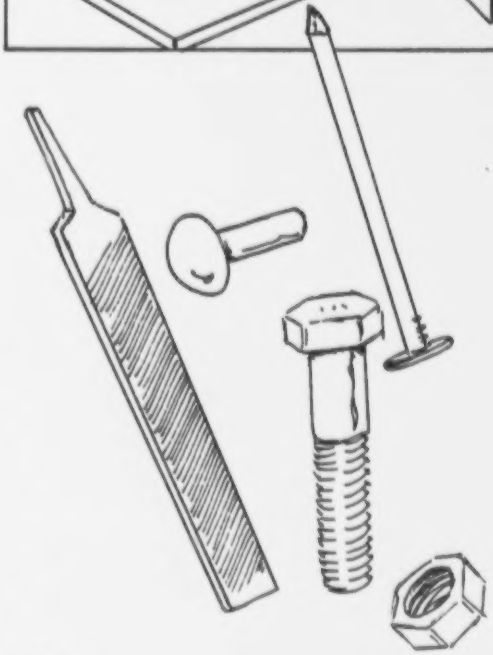
2. **Low Carbon Steel** - used in nails, structural steel, etc.



3. **Medium Carbon Steel** - used in axle shafts, machine gears, high grade bolts, etc.

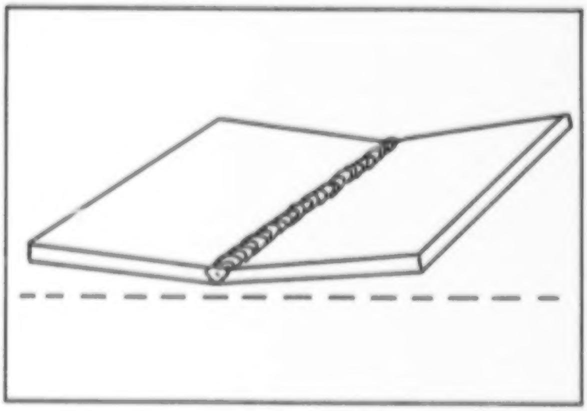
4. **High Carbon Steel** - used in springs, chisels, files, etc.

5. **Cast Iron** - used in machine parts, stoves, large pipes, etc.



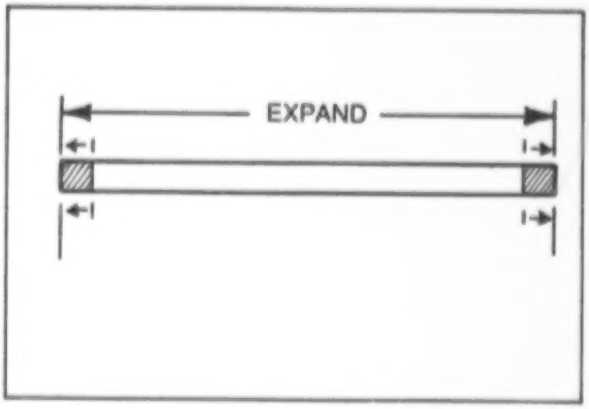
B. Understanding and Controlling Distortion

1. Metals often bend when they are welded. This bending is called distortion.

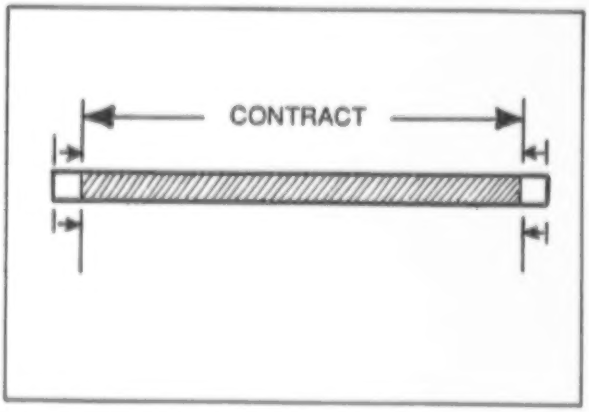


2. Distortion is caused by the expansion and contraction of metal.

   - Metal expands (becomes larger) when it is heated during welding.

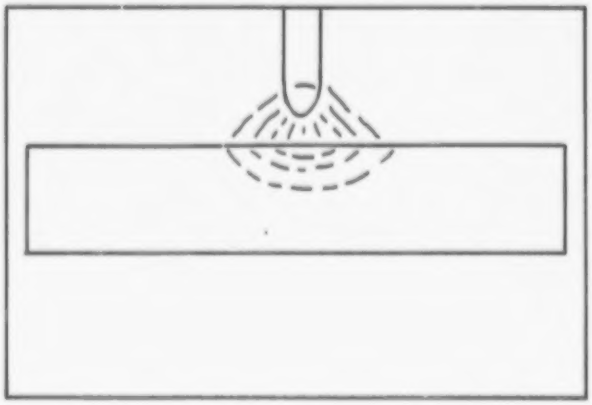


   - Metal contracts (becomes smaller) when it cools after welding.



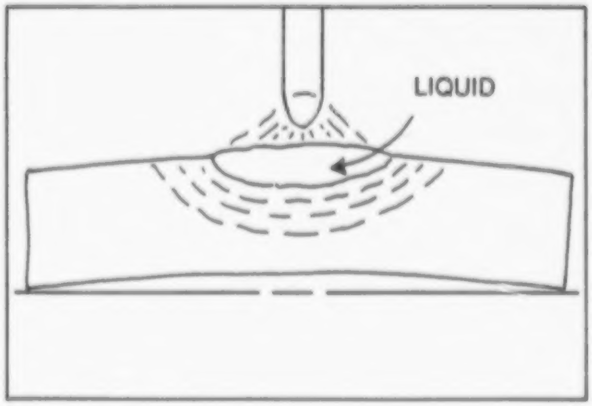
3. Here is an example of how expansion and contraction distort metals during and after welding.

   - An arc is struck in the center of a straight steel bar.



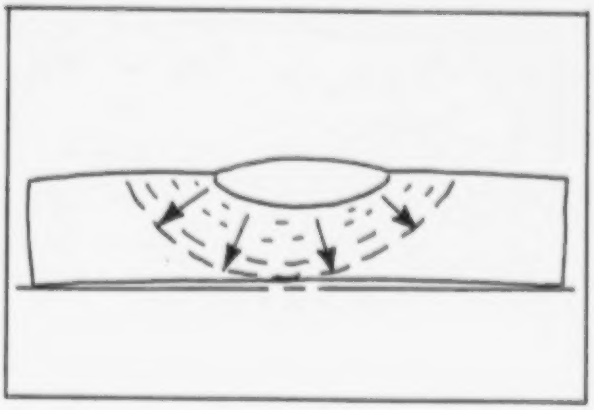
   - The top side of the bar is heated rapidly, which causes the top side to expand.

   - The bottom side of the bar is heated more slowly, so it does not expand as fast as the top side.

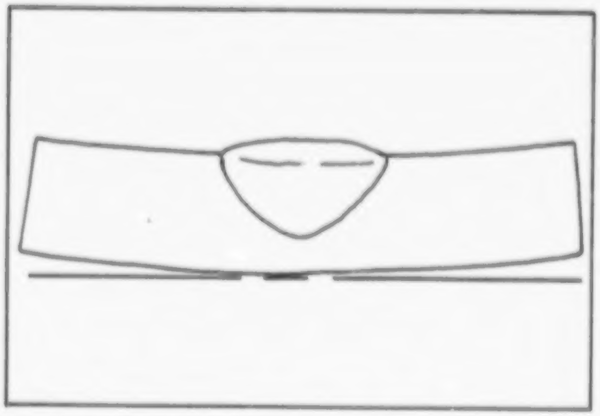


   - This difference in temperature between the bar's top and bottom sides makes the bar become convex (⌢) or bow-shaped.

- Once the arc is removed, the weld zone begins to cool. Some of the heat from the weld zone flows into, and softens, the surrounding metal.



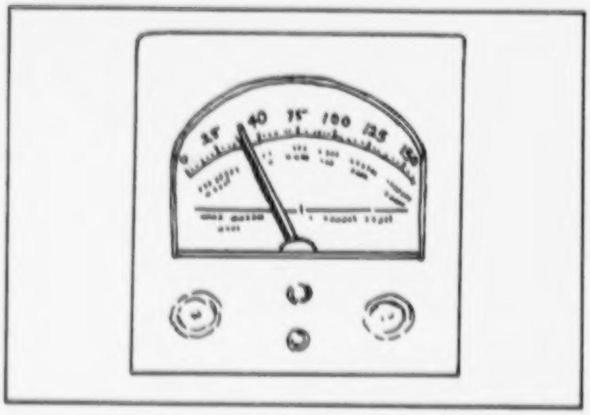
- The metal in the weld zone contracts as it cools. The cooling causes the bar to become concave (‿) in shape.



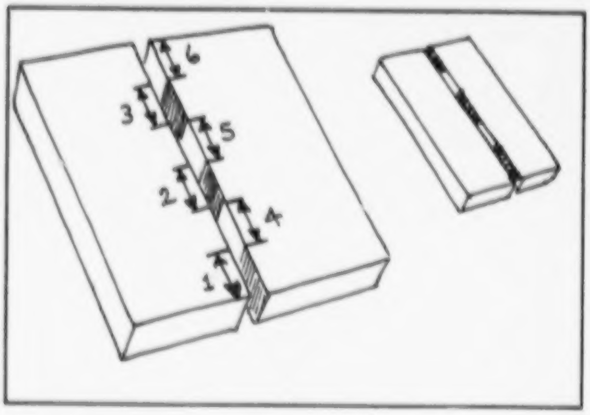
- When the metal plate has completely cooled, it remains bowed. Because its shape has changed, "distortion" has occurred.

4. A welder can do several things to help eliminate distortion. He or she can:

   - Select the lowest amperage setting possible for adequate penetration. Lower amperage helps prevent distortion by limiting the amount of heat in the metal.

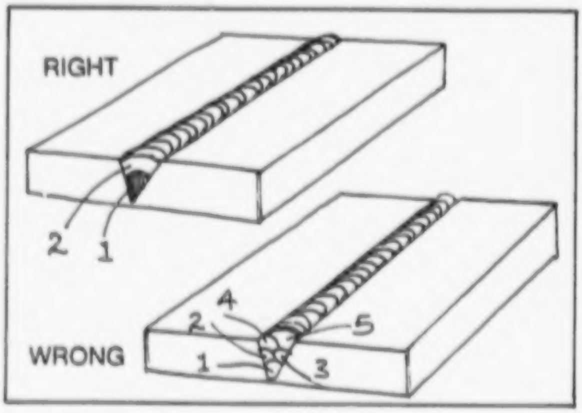


   - Make intermittent welds instead of long, continuous welds. Intermittent welding limits the amount of heat buildup in the metal.

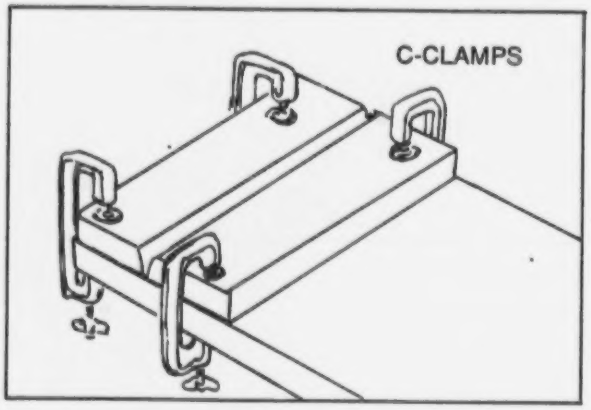


   - Use the least number of weld passes possible for a good weld.

     Also use the narrowest weld bead possible. As before, these techniques reduce distortion by limiting the amount of heat buildup in the metal.

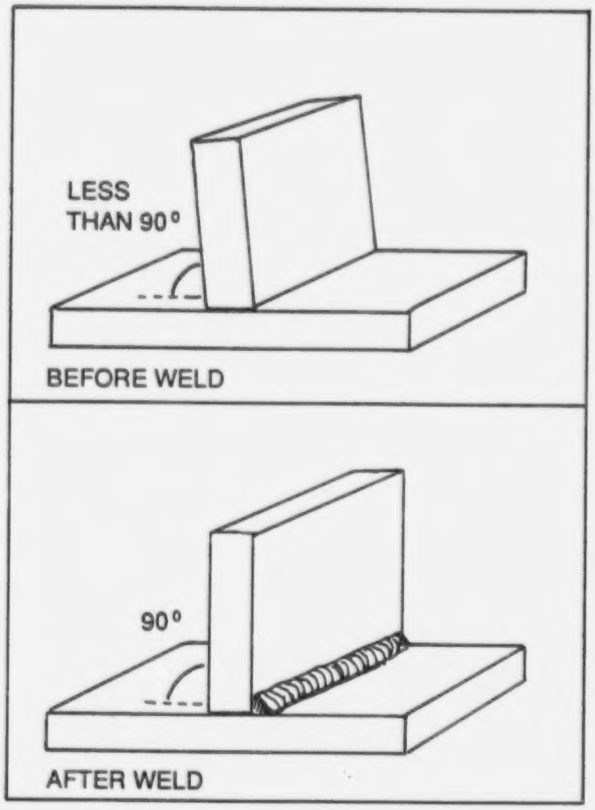


- Clamp the metal securely before welding. Clamping keeps the metal from moving and helps prevent distortion.



5. Skillful welders make distortion work for them.

   Since they know metal will distort when welded, experienced welders set the metal slightly out of alignment before welding. Distortion then draws the metal into the proper position as the weld cools.

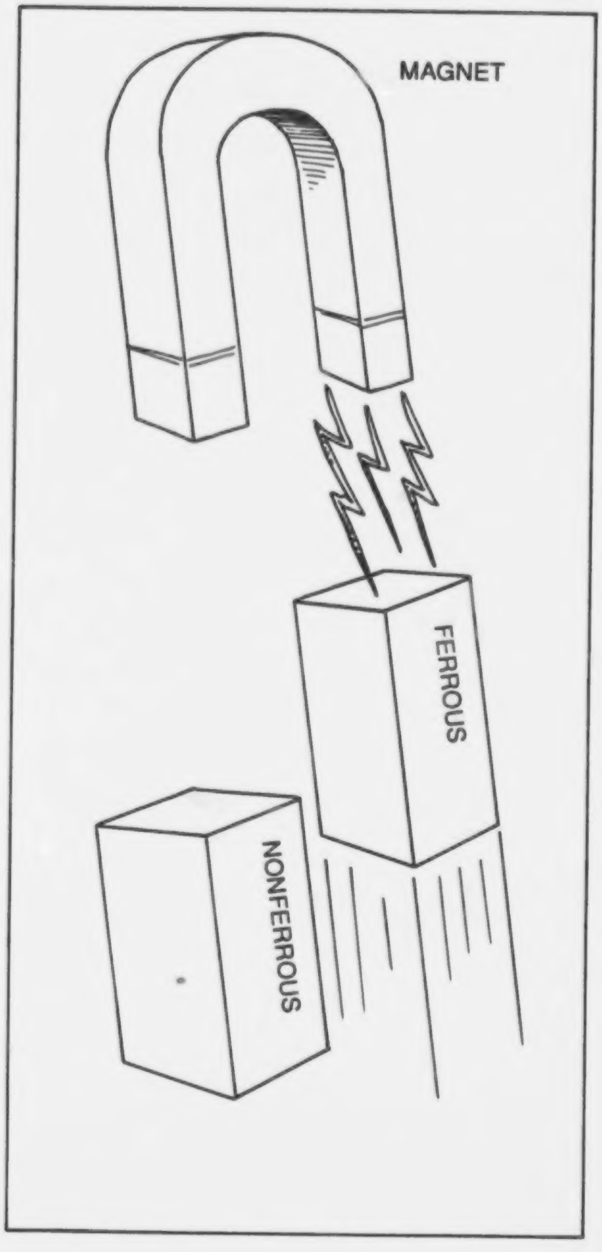

LESS
THAN 90°
BEFORE WELD
90°
AFTER WELD

B. Types of Metals and Their Uses

1. There are two major types of metal: ferrous and nonferrous.

2. **Ferrous** metals are metals that contain iron.

   Steel, cast iron and stainless steel are examples of ferrous metals.



3. **Nonferrous** metals are metals that do not contain iron.

   Aluminum, magnesium, copper and brass are examples of nonferrous metals.

4. Most ferrous metals are magnetic. Nonferrous metals are not magnetic.

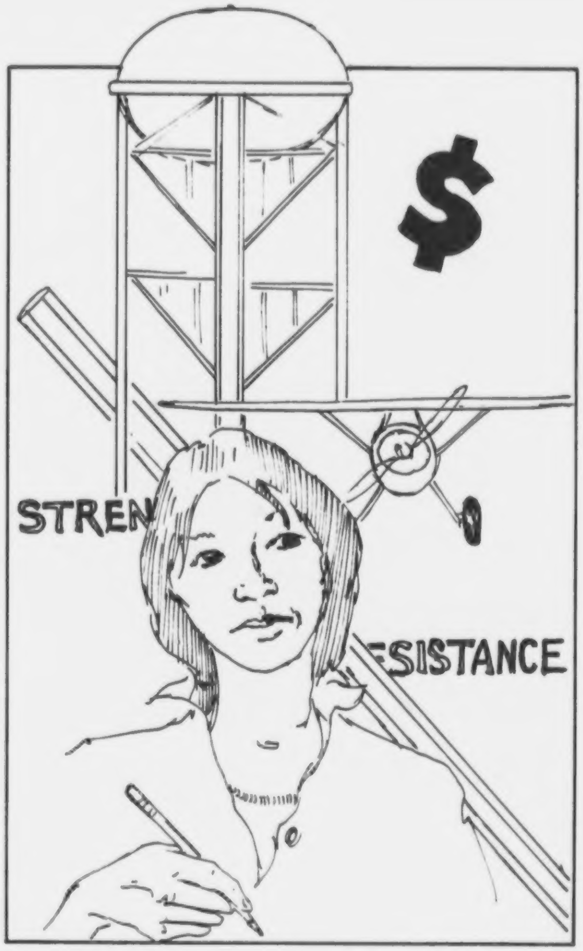
   NOTE: This rule does not work in all cases.

   Stainless steel is a ferrous metal. However, high quality stainless steel is not magnetic.

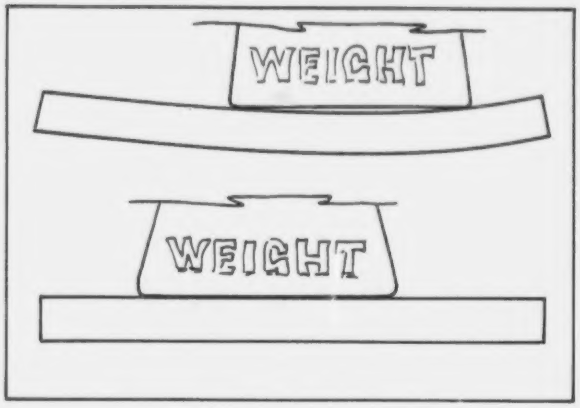
5. The best type of metal to use for any product depends on many factors.

   When selecting a metal, the designer must consider the:

   - use for the finished product
   - appearance of the metal
   - rust resistance of the metal
   - cost of the metal
   - strength of the metal
   - weight desired in the finished product



6. Sometimes the physical properties of a metal type can change. For example, 1/4-inch aluminum can be stronger than 1/4-steel if the aluminum is produced in a special way.



7. Expense is a factor to consider--how much will it cost:

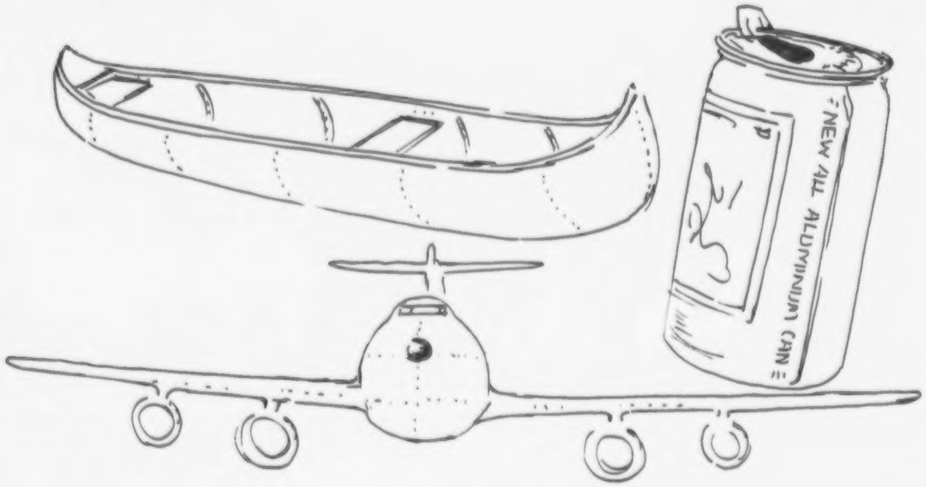
   - to make?
   - to weld?
   - for the consumer to buy?

The table below lists some important characteristics of common metals.

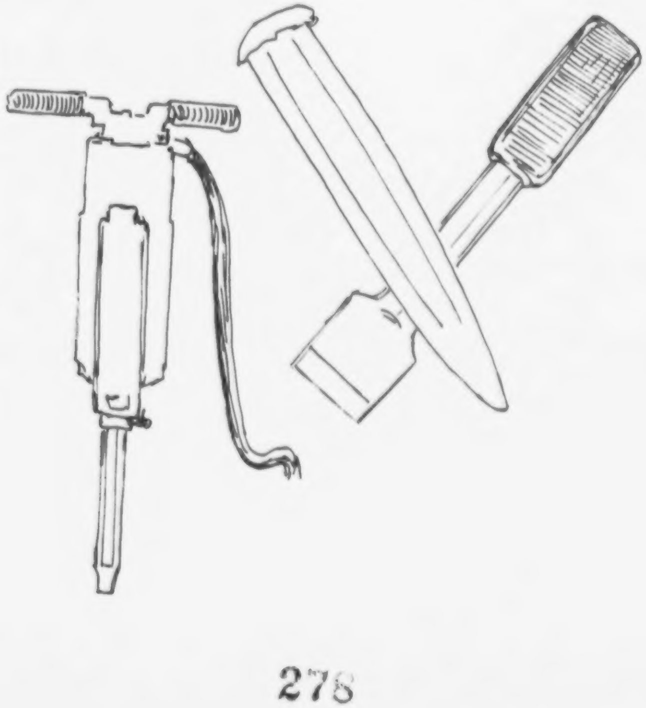
Type of Metal	Weight	Rust Resist.	Magnetic	Cost	Ease of Welding	Flexibility	Heat Resist.
Steel	Med	Poor	Yes	Low	Easy	Good	Poor
Cast Iron	Med	Poor	Yes	Low	Diff.	No Flex.	Excell.
Stainless Steel	Heavy	Good	Some are	High	Easy	Good	Good
Aluminum	Light	Excell.	No	Mod.	Easy	Good	Poor
Magnesium	Very Light	Excell.	No	Very High	Easy	Good	Poor
Brass	Med	Excell.	No	High	Easy	Good	Poor
Copper	Med	Excell.	No	Mod.	Easy	Good	Poor

7. The characteristics of metals determine how the metals will be used. For example:

Aluminum is light, rust resistant, easy to weld and moderate in cost. These properties make it an excellent metal for such things as airplanes, cans and canoes.



High Carbon Steel can be heat treated to make it very hard. This quality makes it an excellent material to use in tools that are struck, such as chisels and punches.



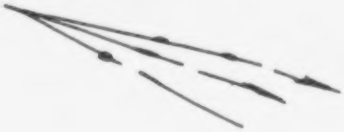
C. Using the Spark Test to Identify Ferrous Metals

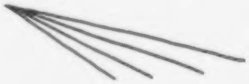
1. Ferrous metals give off sparks when placed against a grinding wheel.

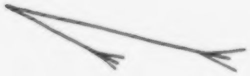
2. Ferrous metals can be identified by their sparks. Different ferrous metals give off sparks that differ in length, density, color and explosiveness. See the illustrations below.

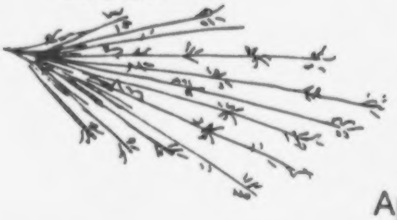
   (NOTE: Nonferrous metals do not give off sparks when placed against a grinding wheel. Therefore, other methods must be used to identify nonferrous metals.)

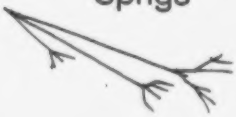
   The following terms are used when describing the results of spark tests:

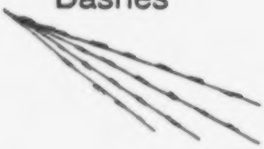

Bud Break Arrow

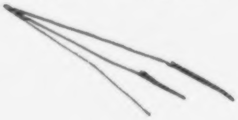

Shaft


Fork

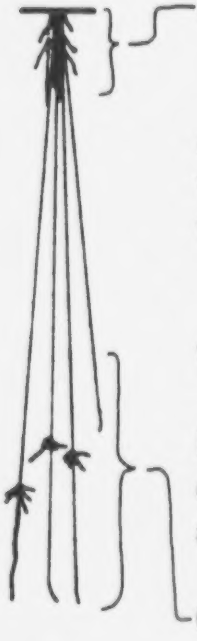

Stream


Sprigs


Dashes


Appendages

WROUGHT IRON



Color - straw yellow

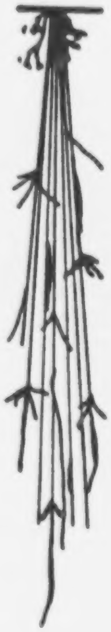
Average stream length with power grinder varies with pressure

Volume - large

Long spark shafts that end in forks and arrowlike appendages

Color - white

LOW CARBON STEEL



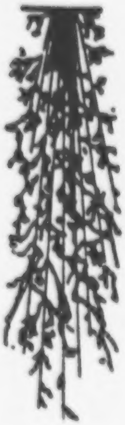
Color - white

Average stream length with power grinder varies with pressure

Spark shafts are shorter than wrought iron's and end in forks and appendages

Forks become more numerous, and exploding sparks increase as carbon content increases

HIGH CARBON STEEL



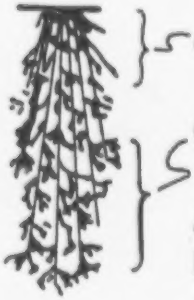
Color - white

Average stream length with power grinder can go up to 55 inches, varies with pressure

Volume - large

Numerous small and repeating sparks that explode

GRAY CAST IRON



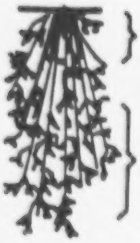
Color - red

Color - red

Average stream length with power grinder can go up to 25 inches, varies with pressure

Volume - small

WHITE CAST IRON



Color - red

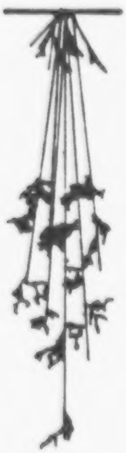
Color - white

Average stream length with power grinder can go up to 20 inches, varies with pressure

Volume - very small

Sprigs - finer than gray iron. Small and repeating.

MALLEABLE CAST IRON



Color - straw yellow

Average stream length with power grinder can go up to 30 inches, varies with pressure

Volume - moderate

Longer shafts than gray iron, ending in numerous small, repeating sprigs

ACTIVITY SHEET 1

OBSERVE DEMONSTRATION OF HEAT TREATING OF HIGH CARBON STEEL

Directions: Your instructor will provide a demonstration of heat treating of high carbon steel. As you observe the demonstration, check off each of the following points.

[NOTE TO THE INSTRUCTOR: After the demonstration, explain the concept of metal hardening. Discuss the situations in which this procedure might be used.]

High carbon steel can be hardened in a number of ways. In this demonstration, the water hardening method will be used.

_____ 1. Secure a piece of high carbon steel rod and file a notch along one side. Notice that the file easily marked the metal.

_____ 2. Take the rod to an oxyfuel welding station.

_____ 3. Elevate the rod so it can be heated evenly.
(Stand the rod on end or tack weld it to a piece of strapsteel and clamp it in a vise.)

_____ 4. Light the torch and adjust it to a neutral flame. Heat the top three fourths of the rod to a bright red color. Hold the flame there for 4-5 minutes to ensure the rod is evenly heated.

_____ 5. Shut off the oxyacetylene flame.

_____ 6. Using a pair of pliers, quickly quench (dunk) the piece completely under water. Move the metal rapidly in a circular motion to speed cooling.

[CAUTION: Do NOT remove the metal from under water until it is cool. Steam may rise from the water and burn you.]

_____ 7. Now try to file a notch beside the area you filed before.

_____ 8. Notice that it is now very difficult to notch the rod. It is difficult now because high carbon steel, when heated and rapidly cooled, becomes very hard.

METALLURGY

UNIT REVIEW

Pick the word that best fits the statement.

a. contraction
b. ferrous
c. nonferrous
d. distortion
e. expansion

1. Metal that does not contain iron ____________
2. The bending of metal pieces caused by expansion and contraction ______________
3. The process of shrinking or making smaller _____________
4. Metal that contains iron _____________________________
5. The process of making an object bigger ______________

Answer the following questions:

6. What happens to metal when it is heated? ________

____

When it cools? ____________________

____

7. What are at least three things a designer must think about when selecting the metal for a project?

a. ______________________________

b. ______________________________

c. ______________________________

8. Put an "X" beside each statement that describes something a welder can do to avoid problems from expansion and contraction of metal.

a. ___ Select the lowest amperage setting that will result in adequate penetration.

b. ___ Make intermittent welds instead of long, continuous welds.

c. ___ Use twice as many weld passes as required.

d. ___ Clamp the metal securely in position before welding to keep it from moving.

e. ___ Set the metal slightly out of alignment before welding.

9. Look at each of the spark patterns below and write what type of ferrous metal would produce each spark pattern. The first problem has been done to show you how.

a. white cast iron

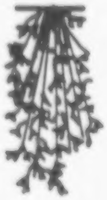
b. ____________

c. ____________

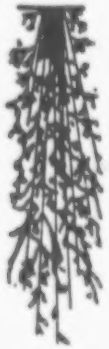
d. ____________

e. ____________

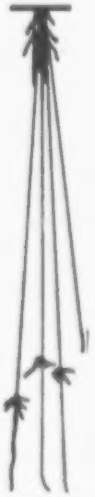
a.



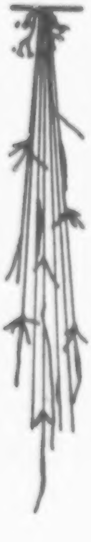
b.



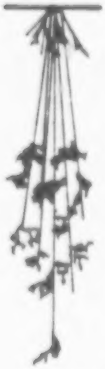
c.



d.



e.



METALLURGY

PERFORMANCE CHECKLIST

Student ______________________________ successfully performed the following tasks:

	Yes	No	Comments
1. Described how metal reacts to heat			
2. Identified uses of different types of metal			
3. Identified ferrous metals in a spark test			
4. Observed demonstration of heat treating			

Satisfactory - should move on ☐

Should repeat this unit ☐

____
Student's Signature/Date

____
Instructor's Signature/Date

"END OF DOCUMENT"